NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

THESIS

INTEGRATION OF COMPUTER-AIDED ACQUISITION & LOGISTIC SUPPORT (CALS) COMPONENTS INTO THE ROK ARMY INFORMATION INFRASTRUCTURE

by

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September, 1995

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE September 1995	3. REPORT TYPE AND DATES COVERED Master's Thesis

4. TITLE AND SUBTITLE INTEGRATION OF COMPUTER-AIDED ACQUISITION AND LOGISTIC SUPPORT (CALS) COMPONENTS INTO THE ROK ARMY INFORMATION INFRASTRUCTURE	5. FUNDING NUMBERS
6. AUTHOR(S) Jun Sang Jo	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER:
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER:

11. SUPPLEMENTARY NOTES
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*
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Having described the Continuous Acquisition and Life-cycle Support (CALS) information management system (IMS) employed by the United States military to maintain and distribute technical support documents for weapons and materials, this thesis proposes an overall strategy for integrating the information management concepts of CALS into the infrastructure of the Army of the Republic of Korea (ROK).

14. SUBJECT TERMS Computer-Aided Acquisition and Logistic Support (CALS), Joint Computer-Aided Acquisition and Logistic Support (JCALS)	15. NUMBER OF PAGES: 126
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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INTEGRATION OF COMPUTER-AIDED ACQUISITION & LOGISTIC SUPPORT (CALS) COMPONENTS INTO THE ROK ARMY INFORMATION INFRASTRUCTURE

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE INFORMATION TECHNOLOGY MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
SEPTEMBER 1995

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ABSTRACT

The goal of the CALS initiative is to enable integration of enterprises on a worldwide basis. The vision is for all or parts of a single enterprise, or for example, an original equipment manufacturer and its suppliers, or a consortium of public and private groups and academia, to be able to work from a common digital database, in real time, on the design, development, manufacturing, distribution and servicing of products. The direct benefits would come through substantial reductions in product-to-market time and costs, along with significant enhancements in quality and performance.

Having described the Continuous Acquisition and Life-cycle Support (CALS) information management system (IMS) employed by the United States military to maintain and distribute technical support documents for weapons and materials, this thesis proposes an overall strategy for integrating the information management concepts of CALS into the infrastructure of the Army of the Republic of Korea (ROK).

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I. INTRODUCTION

A. BACKGROUND

This thesis describes the Continuous Acquisition and Life-cycle Support (CALS) information management system (IMS) employed by the United States military to maintain and distribute technical support documents for weapons and materials. CALS also serves as a primary tool used in the procurement process of these commodities, providing a mechanism for consistent and cost-effective acquisition. Additionally, this thesis proposes an orientation for integrating the information management concepts of CALS into the infrastructure of the Army of the Republic of Korea (ROK).

In today's rapidly evolving high-technology environment neither industry nor government — including the United States Department of Defense (DoD) — could operate efficiently with paper-based information processes. In the past, technical manuals containing engineering drawings, illustrations, and textual data used to support weapons systems and materials were developed and delivered to the United States government in paper form. The problems inherent to paper-based technical manuals are well illustrated by the following example. In 1980 the M1 tank was delivered to the U.S. military with approximately 40,000 pages of technical data and 8,000 engineering drawings for maintenance, whereas, in 1960 the M48 tank required only 10,000 pages of documentation. The U.S. Navy's problem was greater: the USS Vincennes has 23.5 tons

of paper representing systems and structures above the main deck — more tonnage of paper than of all the weaponry on board. Many inaccuracies were found within these paper-based manuals. In 1992 about 10,000 technical manual discrepancies were reported, and the correction of these discrepancies was a very costly (up to $2,000 per page) and time consuming job. [Ref. 2: p. 21]

In the mid 1980's the DoD sought to capitalize on advances in computer hardware and in the areas of computer-aided design, computer-aided engineering, and concurrent engineering. The DoD structured a series of military specifications and standards facilitating the handling of weapons systems' technical data in open, digital formats. This pioneering effort grew into a joint DoD-Industry CALS initiative leading to procedures governing acquisitions from defense contractors through DoD acquisition managers conducted with technical data in digital formats. With this change there arose a need for information management systems that could receive, store, and manipulate technical data in various formats. Additionally, many of the acquisition management procedures required "reengineering," applying concepts such as Business Process Reengineering (BPR) to reap the benefits of receiving, handling, and managing technical data in digital formats. [Ref. 4: p. 1]

Meanwhile, major subcontractors began to implement Electronic Data Interchange (EDI) contracting programs with their smaller suppliers. The President of the United States made a commitment in an October 1993 Executive Order to start using EDI in new procurement systems currently being developed across all federal agencies. The largest of

the United States procurement agencies, the DoD, is notifying its existing and potential suppliers that all simplified acquisition procurement actions will be electronically based by the year 1997. In support of this action, the United States Congress raised the simplified acquisition procurement level from $25,000 to $100,000, contingent upon this electronic achievement in the FY '95 DoD Budget resolution. The CALS strategy and government and industry mechanisms now being defined and implemented can help make it happen. [Ref. 7: p. 11]

Using CALS as a model, countries on the Pacific Rim and in Europe are realizing the potential benefits and comparative urgency of implementing a similar acquisition strategy. Several countries have been holding individual or group CALS Conferences during the last few years, such as CALS Pacific '94, CALS Japan '94, and CALS Australia '94.

The concepts and utility of CALS have also sparked discussion in Korea. The Korean Ministry of National Defense (MND) has developed new weapons systems (e.g., the Army's K1 tank, the Air Force's Korean Fighter Program (KFP), and a destroyer class of ships and the first submarine in the Navy) using some non-integrated, industrial, CALS-compatible applications (e.g., EDI, SGML, CAD, CAM, etc.). Recently, however, the MND has recognized the relevance and significance of integrated CALS concepts for its new weapon systems, as well as implementing CALS support for older ones. Currently, the CALS Committee of the Computer and Communication Promotion Association of Korea (CCPAK) plays the leading role for CALS activities on the industrial

side. On the government side, the Ministry of Information & Communication (MIC) and the Ministry of Trade, Industry & Energy (MTIE) has established long term plans for implementing CALS. Also MND is studying the issue to develop a basic plan for Korean CALS implementation. In the future, more detailed plans will be developed by the Korea Institute for Defense Information System (IDIS), and, the Agency for Defense Development (ADD) is slated to develop an Integrated Weapons Systems Data Base (IWSDB) as a model for the services. [Ref. 5]

B. WHAT IS CALS?

1. CALS Origin

CALS began in the mid-1980's as a defense industry project to exchange technical data directly with the government in electronic format rather than on paper-based documents. [Ref. 2: p. 17] After CALS became an official program, the CALS/CE (Concurrent Engineering) Industry Steering Group was established. This group tried an integration of various existing information technologies to achieve their initial goals, continuously adding new elements as their purposes changed.

The early CALS goal of electronic interchange of technical data directly with the government was prompted by the knowledge that paper-based information is expensive to produce and difficult to maintain. Both industry and government reasoned that electronic data would be easier to generate, distribute, and maintain, requiring less storage space, and being less costly and more timely to update and maintain.

The "CALS" acronym has evolved over time. In 1985, CALS began as "Computer Aided Logistic Support," defined as transiting from paper-based weapons systems acquisition and support processes to an integrated and automated environment. This effort produced, essentially, an electronic document management and EDI system.

By 1988 the name expanded to include "acquisition," becoming "Computer-aided Acquisition and Logistic Support." The new name represented a two-phase approach to implementation that was adopted with the long term (year 2000) goal of a shared, integrated database. In August 1988, the Deputy Secretary of Defense directed that routine contractual actions be implemented with CALS throughout DoD. Instead of simply better management of technical data, sharing and integration of data enabled overall improvements in productivity and quality. The significance of these benefits was recognized by government and industry alike, and today the CALS strategy is being adopted and adapted by organizations the world over.

In 1993, the definition of the project was changed again to "Continuous Acquisition and Life-cycle Support." According to the official Proceedings of the Seventh Annual Conference (CALS EXPO International '94), jointly sponsored by DoD, the Department of Commerce and the CALS/CE Industry Steering Group, "this most recent change was meant to reflect the fact that CALS is really about information and process improvement, and that both are continuous and recognizes CALS as a facilitator for world wide process improvement and enterprise integration." [Ref. 2: p. 17] Much of the basic technology to allow the initial goals of EDI is now available, and, as stated earlier, the

President of the United States made a commitment in an October 1993 Executive Order to begin using EDI as part of new procurement systems now being developed across all the Federal agencies.

The emphasis of the CALS program continues to evolve as goals are achieved, technology matures, and theories of business management change. Today, a greater emphasis is placed on "reinventing government" and "continuous process improvement." CALS has been looked at in this new light to ensure that it is coordinated with new ways of doing business. There is new emphasis on the underlying process instead of just automating what has always been done before.

2. Definition of CALS

Because CALS covers such a broad scope, it can be defined in various ways to suit the context of its use.

a. DoD Aspect

To meet the challenge of ensuring the capability and readiness of DoD forces in view of a threat that has been radically altered and is ever changing, a budget that is substantially declining, and global technology that is advancing rapidly, DoD must improve or reengineer its functional processes to decrease its weapon systems life-cycle costs. In the CALS Strategic Plan, DoD defines CALS as "a government and industry strategy intended to enable more effective generation, exchange, management, and use of digital information that supports the life cycle of a product through the use of national and

international standards, business process changes, and advanced technology application." [Ref. 3]

b. CALS Industrial Steering Group (ISG) Aspect

The position of CALS ISG, while not unlike the government view in basic concepts, is distinguished by its greater emphasis on the organizational rather than purely informational, aspects of CALS as a solution to many of current business problems. As a solution, CALS has following benefits:

- *Providing longevity of information*: CALS uses international standards, assuring access to information created daily, ten or twenty years from now when software and hardware have evolved dramatically.

- *Meeting client and user needs*: Providing timely access to information within an organization and between business partners, an organization can better meet the needs of its internal users, e.g., reducing data re-entry as well as the needs of external clients by providing better products quickly and less expensively.

- *Remaining competitive*: Costs are reduced with the ability to rapidly access and exchange information within divisions of organizations, with suppliers, and with business partners. Organizations are able to reduce their costs, while producing more product, thus insuring their long term viability.

- *Eliminating inefficiency of paper-based systems*: CALS is based on electronic file formats. Creating, exchanging and using information in electronic form eliminates much of the paper that currently exists in offices.

- *Reducing costs while producing higher quality products*: Shortens the production cycle of products while allowing implementation of flexible approaches to manufacturing and access to contracts requiring CALS compatibility.

Based on these benefits, the CALS Industry Steering Group recently defined CALS as “a global strategy to further enterprise integration through the streamlining of business processes and the application of standards and technologies for the development, management, exchange, and use of business and technical information." [Ref. 2: p. 18]

3. CALS Vision

a. DoD Aspect

CALS' vision is embodied in the DoD’s stated strategic goals and objectives as presented in the CALS Strategic Plan ‘93. In this plan, the DoD set goals for the advancement and application of CALS. Each goal has supporting objectives, as shown in the list below:

- To expand its relationship with industry to ensure more harmonious methods of operation and data exchange. Warfighting capability, the readiness of forces, and effective combat operations, depend in large part upon the DoD’s ability to capitalize on technological and manufacturing capabilities of the U.S. industrial base. The DoD is reforming its acquisition process to lower acquisition and life-cycle costs of products it buys and use more commercial items. Supporting objectives are: (a) Develop a DoD and industry infostructure; (b) Enable “dual-use” technologies; (c) Harmonize standards and practices; and (d) Provide CALS expertise through education and training.

- To complete the transition of its active information and business transactions to standard electronic formats. Achieving the full potential of many business process changes depends on acquiring, accessing, and processing data digitally. Active data need to be converted to a standard digital format, and the infostructure to process digital data must be in place. Considerable digital information must be available before the DoD and industry can realize benefits from the CALS infostructure. Supporting objectives are: (a) Modernize hardware and

software; (b) Acquire new digital data; (c) Convert existing data to digital form; and (d) Conduct business transactions in digitally.

- To continue progress toward integration of the DoD's digital information. This goal supports changes to business processes by improving availability and accuracy of information. CALS will create the environment for a seamless, transparent, and distributed management of business and technical information significantly improving information availability. Authorized users can access this information to perform many functions throughout a system's life cycle. The development of a DoD-wide information entity and data model with full attributed data elements is a key component of this effort and necessary to its success. Supporting objectives are: (a) Develop an integrated infostructure; (b) Align the Defense Integrated Infostructure (DII) with the National Information Infrastructure (NII); and (c) Promote business process reengineering.

b. Industrial Aspect

The CALS ISG addressed a vision statement more concerning industrial side. The vision is for all or part of a single enterprise (e.g., an original equipment manufacturer and its suppliers, or a consortium of public and private groups and academia), to be able to work from a common digital database, in real-time, on the design, development, manufacturing, distribution and servicing of products. Direct benefits would be realized through substantial reductions in product-to-market time and costs, along with significant enhancements in quality and performance.

C. WHY DOES THE ROK ARMY NEED CALS?

Since the Korean War, the United States Forces in Korea (USFK) have played an important role in maintaining the security of the Korean peninsula. In March 1977, the Carter Administration announced its plan to withdraw all U.S. ground troops from Korea.

Furthermore, the cessation of the Cold-War increased the possibility of local conflicts. From the early 1970's, Korea was stirred to develop a self-reliant defense posture by various international environments. As a result, MND decided that a self-reliant defense posture should become a priority for Korean national defense.

Korean defense logistics relied upon U.S. military aid until the 1960's. In the 1970's MND started to build a self-reliant defense logistics support system; and during the 1980s it developed into uniquely Korean system. [Ref. 6: p. 173] Also MND mentioned in the Defense White Paper that "the future logistics environment will feature internationalization, with military procurement sources diversified and the importance of information highlighted." With the goal of establishing a self-reliant logistics support system, MND has focused on developing a comprehensive defense logistics support system, improving military supply systems and actively promoting international logistics cooperation.

By the definition of CALS, CALS is a global strategy for government and industry in the acquisition and logistics fields. To achieve efficient management of defense logistics resources, CALS could be a positive strategy for the Korean Military. The ROK Army also needs CALS for cost reduction. As mentioned earlier, reliance on paper-based processes has become exceedingly expensive. In the Defense White Paper, the Korean defense budgets' proportion of the GNP is moving downward, from 5.2% in 1988 to 3.46% in 1993, with forty-five percent of the Korean defense budget allocated for logistics support. This situation warrants the most cost effective logistic system available.

Consequently, implementation of CALS into the Korean Army Information Infrastructure is a reasonable consideration.

D. SCOPE OF THESIS

The objective of this thesis is to propose an implementation strategy of CALS as applies to the ROK Army. After the Joint Computer-aided Acquisition and Logistics Support (JCALS) structure is reviewed, application areas that are proposed or expected at the DoD level will be analyzed. This thesis utilized implementation lessons from the U.S. CALS, and, in that light, reviews the Korean CALS. Afterward, an implementation strategy will be suggested for the Korea Army.

The thesis will be structured as follows. Chapter II, JCALS, Architecture and Components, describes requirements for the DoD CALS infrastructure modernization (JCALS). Chapter III, CALS Standards for Interoperability and Integration, mentions standards for JCALS system, EDI and Contractor Integrated Technical Information Services (CITIS). Chapter IV, Application Focus Area, presents the applications which the prototyping JCALS site has tested, or plans to test. Chapter V, Recommendation for ROK Army, proposes a CALS implementation strategy for ROK Army. Chapter VI presents the final conclusion.

II. JCALS : ARCHITECTURE AND COMPONENTS

In CALS' strategic plan, the DoD defines goals and objectives that it will pursue in applying CALS throughout the Department of defense. It will apply CALS to all information – business and technical – used between and within the DoD, and its industrial partners. Implementation of the CALS vision includes infrastructure of the DoD, standards, policy, and regulatory considerations. [Ref. 3]

As CALS implementation guides, DoD published guides *MIL-HDBK-59A* on 28 September, 1990 and *MIL-HDBK-59B* on 10 June, 1994. These guides provide information and guidance for applying CALS strategy to the acquisition, management and use of digital data in support of defense weapons systems and equipment. Specific attention is given to detailed planning and contractual implementation of CALS requirements. Also, the Department of Navy (DoN) published the *Navy/Marine Corps Manager's Desktop Guide for CALS Implementation* on 30 September, 1994. This guide provides a compilation of the Navy's direction and intent for the incorporation of CALS into defense system programs.

A. WHAT IS JCALS

JCALS is the DoD CALS infrastructure program employed to embody CALS concepts. While CALS itself is a global strategy on the part of both industry and the DoD, JCALS was developed from Army CALS (ACALS). In January 1991, the U.S.

Army was directed to include the joint requirements and provide design, development, acquisition, and implementation options for a joint program.

The Program Manager JCALS office defines that JCALS is a multi-site, interactive, distributed data information and management system. PM JCALS is a Joint Office tasked with creating a digital environment which actively supports the implementation of the acquisition and logistics requirements of the services and Defense Logistics Agency (DLA). [Ref. 13]

The DoD CALS infrastructure program, presently known as JCALS, provides an information management system to support uniform logistics, acquisition, engineering, manufacturing, configuration management, materiel management, and other life-cycle functional processes.

To test JCALS in each of the services and ensure customer involvement and satisfaction early in the design and development stages of the system, six prototyping sites have been identified:

- ***USAF*** Oklahoma City Air Logistics Center (OC-ALC), Tinker Air Force Base, Oklahoma.
- ***USAF*** Warner Robins Air Logistics Center (WR-ALC), Robins Air Force Base, Georgia.
- ***USA*** U.S. Army Missile Command (MICOM), Redstone Arsenal, Huntsville, Alabama.
- ***USA*** U.S. Army Printing and Publications Command, Alexandria, Virginia.
- ***USMC*** Marine Corps Logistics Base (MCLB), Albany, Georgia.

- *USN* Port Hueneme Division (PHD), Naval Surface Warfare Center, Port Hueneme, California. [Ref. 10: pp. 2-1]

The prototyping sites are the real part of the CALS implementation within the DoD. A prototype system is a model, an experiment, and at best a preliminary version of a real system. Prototypes are used as the final design illustration of a system to both users and designers and, as such, are real, manipulatable, and can be adjusted. [Ref. 9] The requirements applied to prototyping sites follow the CALS standards and implementation guides such as MIL-HDBK-59A & B and the Navy/Marine Corps Manager's Desktop Guide for CALS Implementation.

B. GENERAL JCALS SYSTEM DESCRIPTION

1. Deployment

Planned to begin approximately in the last quarter of 1995, the deployment of JCALS systems will be accomplished at approximately 250 military and DLA installations over several years. JCALS, together with Joint Engineering Data Management and Information Control System (JEDMICS), will be a major manifestation of the implementation of the DoD's CALS strategy. [Ref. 16]

JCALS sites, each of which is supported by its own Fiber-Optic Distributed Data Interface (FDDI) backbone and departmental LANs, will be interconnected by a WAN that relies on DISN assets and capabilities. The connectivity offered by the WAN as well as the configuration of each JCALS site is depicted in Figure 2-1.

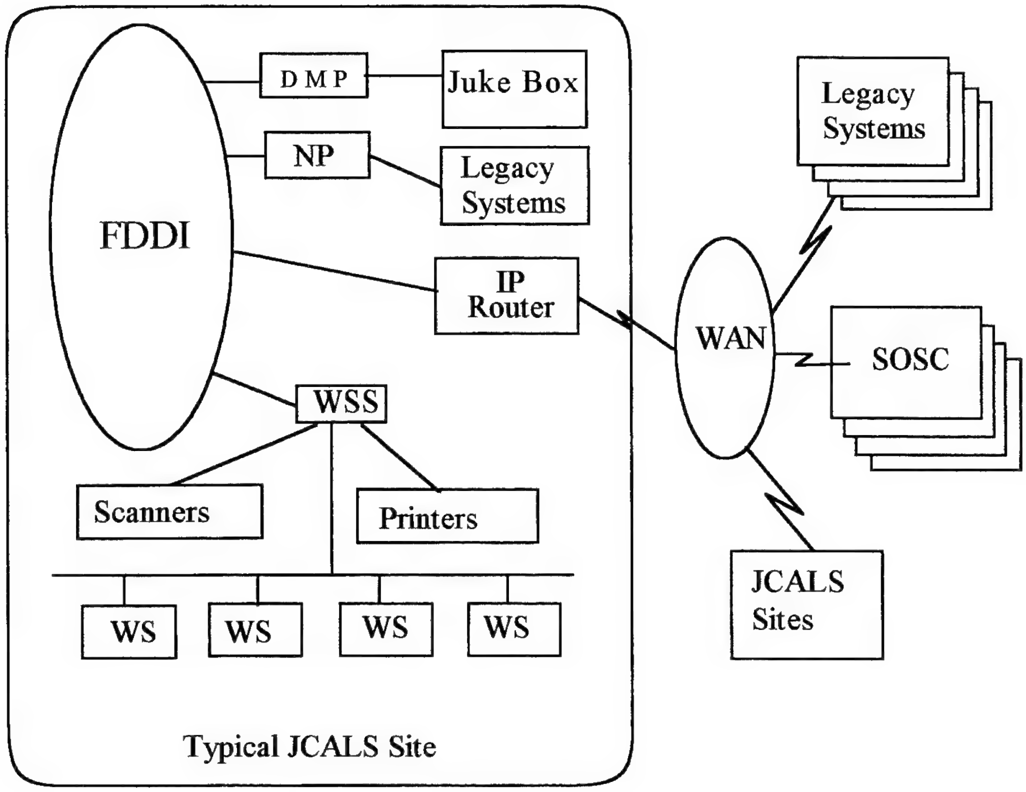

Figure 2-1. JCALS Architecture.

2. Infrastructure

The JCALS system is an open architecture design. This design style provides for the future, and is also an environment that can easily be modified to keep pace with changing computer technology and that can easily be tailored to local requirements. For example, peripheral equipment that are required at particular JCALS sites can be accommodated by simply adding them to the initially deployed system and, since a very high percentage – approximately 95% – of the system software is COTS

(commercial-off-the-shelf), applications can be changed or added with relative ease. Even though each site can utilize differing quantities and types of peripheral equipment, the basic configuration at each site will be functionally identical.

The infrastructure of JCALS system should include several means of communicating over geographic distances that provide the JCALS users powerful tools for accomplishing a large percentage of their daily tasks. These means include: the JCALS Workflow Manager, JCALS Workfolder, JCALS In Box/Out Box utilities, and JCALS Mail system. The infrastructure designed and deployed as JCALS system provides the basis for the DoD to begin implementing the CALS initiative that began in the mid-1980's. The initial functionality included in the initial deployment of the system is the Technical Manual system. [Ref. 16]

3. JCALS Infrastructure Capability Features

Several major features in the JCALS system provide basic infrastructure capabilities that permit fulfillment of the CALS initiative. The following paragraphs briefly describe these features. [Ref. 16]

a. Reference Library/Reference Library Search

A significant portion of the JCALS infrastructure is the Reference Library – a major element of the JCALS distributed data base capability – and the means to search the library for specific documents. The library provides users with an electronic repository for publications, documents, engineering drawings, graphics, etc., that are available in the

JCALS system. This library provides JCALS users with worldwide access to any publication, document, drawing, etc., that they may need. Depending upon an individual's permissions or authority established in their assigned user ID code, they will be able to view and/or revise the source documents contained in the Reference Library. All items in the Reference Library are cataloged based on a number of categories such as data type, subtype, responsible service, proponent, etc. The Reference Library Search capability provides users with a choose/filter window to define criteria that the system will use to locate the exact documents the user desires. [Ref. 16]

b. Workflow Manager

A second major system infrastructure tool provides the means to create and define a sequence of tasks associated with a job and also create a workfolder necessary for that job. Also provided as part of this capability is the capability of monitoring the status of a job as it is being produced and generate a report that shows the status of a job and all in-process tasks. A completed and saved workflow creates all database links that are necessary to associate personnel, data, documents, and time (schedule) to a given job and all of the tasks associated with that job. [Ref. 16]

c. Workfolder

Another part of the JCALS system that is also a major part of the basic system infrastructure tool set is the Workfolder process. This capability, when used in conjunction with the Workflow Manager tool, provides easy access to all data and tools a

user needs to perform assigned tasks. When a task is assigned, a workfolder is automatically delivered to the first task manager (user) through the user's In-Box icon on the Desktop. Once a user opens a workfolder for the first time, it will automatically be placed in the user's Service. The user will retain access to a given workfolder until the job is completed, even though that user might have completed the assigned task. The workfolder does not contain actual data – rather it contains pointers to data that are stored in the JCALS distributed database. Since all of the users working on a job can view and access data simultaneously, the workfolder promotes sharing of information that is necessary for concurrent task efforts. [Ref. 16]

C. JCALS SYSTEM COMPONENTS

A key element of the JCALS System is the distributed information management system, which implements the Integrated Weapon System Data Base (IWSDB). This data base contains data that is physically resident on JCALS hardware and data that is virtually resident in data bases on interconnected existing systems. The information in the data base is available transparently to all users at all sites via the Global Data Management System (GDMS). The JCALS System hardware and software are divided into three major components in the client-server architecture. [Ref. 12]

1. Workstation Management

The Workstation Management component supports all processing and information services to the functional users. It provides all the tools and utilities users require to

retrieve, create, edit, and share technical data, as well as manage and coordinate all work activities involved with the technical processes being automated and standardized. A Workstation Server (WSS) processor, and its associated software and peripheral equipment, functions as server to a group of client workstations connected to it on a work-group LAN. It functions as a client of the Data Management component when access to the IWSDB is required. [Ref. 12]

2. Network Management

The Network Management component consists of all communications hardware and software required to provide secure data communications and connectivity for the JCALS system. It includes local and wide area communications networks to provide common connectivity among JCALS system elements. The Network Management component functions as a server to other components at the same site, and is both a server to – and a client of – the Network Management component at remote sites. For prototyping, the Network Management component is configured on the Data Management Processor. [Ref. 12]

3. Data Management

The Data Management component controls and coordinates the services required to access and manage the Integrated Weapons System Distributed Data Base (IWSDB). In particular, it provides the Global Dictionary/Directory Data Base (GD/DDB) services required to identify and locate information in the distributed GDMS which provides

integrated views of data across multiple JCALS sites and external systems. This component is a server to both local and remote users who need access to data stored on the server. It is also a client of its equivalent component at remote sites where data needed by local users is stored. [Ref. 12]

D. HOST ENVIRONMENT

If data users do not have access to the appropriate hardware, software, and telecommunications equipment, working in a digital data environment can become an obstacle course. Computer hardware must have appropriate processing speed and display capability to run the application software adequately. Application software must perform specific tasks on the data that are required by the user. Rather than re-create data, the appropriate computer networking system should allow users to share data and resources, and telecommunications equipment should allow users to transfer data easily. [Ref. 11: pp. 4-6]

1. Hardware Requirements

Computer hardware consists of the computer processor, memory, monitor, storage devices, and input devices. Most engineering and business single user computers use either an 80486-based processor, a 68040-based processor, or a Reduced Instruction Set Computing (RISC) based processor such as the RS-6000.

The 80486 and 68040 Personal Computers (PCs) are the most widely used computers and are ideal for data-intensive applications that require low- to

medium-graphic displays. RISC workstations are widely used in engineering and technical publishing applications that require either a powerful processor for extensive calculations or a high-resolution graphics display for document editing. A "diskless" RISC workstation may provide a low-cost solution to some engineering computing needs. These workstations typically have a small hard disk for the operating system while the application software and user files are loaded from a network server. A third option is a graphic display workstation that supports the X-Window Motif standard. However, a PC with X-Windows emulation software may provide the same features at lower cost. The standard options for each type of computer is presented in Table 2-1.

Table 2-1. Standard Options for PC Types [Ref. 11: pp. 4-7]

	WINDOWS WORKSTATION TYPE 1	RISC WORKSTATION TYPE 2
Processor	486 DX - 33 / 68040-	RISC Workstation
memory	16 Mb	32 Mb
Media		
Hard Drive	350 Mb	500 Mb
Floppy Drive	3.5 & 5.25	3.5
Tape Drive	Optional	Yes
CD Drive	Yes	Yes
WORM	Optional	Optional
Monitor	17" - 19" Flat SVGA	19" - 21" High Res
Typical Cost	$2,500 to $5,000	$5,000 to $50,000

2. Software Requirements

The JCALS software architecture is based on the use of industry standards to provide an open architecture. From a user's perspective, the most important aspect of the software architecture is that it provides an intuitive, easy-to use interface to the functions performed by the computer system.

The cornerstone of the JCALS software architecture is the graphical desktop. The X-desktop is the selected product as the graphical user front end to the system. X-desktop is a customizable graphical user environment that enables users to configure their working environment. By providing a familiar graphical workspace, X-desktop facilitates the execution of applications software and the management of information in a sophisticated open systems environment.

Aster*x®, a Motif-based office automation package, provides word processing, electronic spreadsheet, and graphics capabilities. This package, together with the calendar, calculator, and electronic mail packages bundled with ULTRIX® MLS+ and X-Windows, satisfies the office automation functional requirements. Workflow management functionality is provided as developed software. These products are augmented by a project management capability provided by the Ultra Planner® package from Productivity Solutions.

In the technical publications area, JCALS has a CALS-compliant publishing solution. JCALS also has a Standard Generalized Markup Language (SGML) capability available through the use of an SGML editor by Arbortext. Technical illustrations will be

produced by Intercap Quickedit® and Intercap Illustrator 2®, which is the selected tool for converting computer-aided design (CAD) drawings into exploded-view, isometric technical illustrations. The actual publishing will be performed using Arbortext's Publisher® and Datalogics CALS Applications software. [Ref. 12]

E. NETWORKS

Deployment of the JCALS production system is envisioned for approximately 250 military and DLA installations. [Ref. 15] They will be interconnected through a DoD worldwide digital telecommunications system managed by the Defense Information Systems Agency (DISA). A user at any site will be able to access data available at any of the other sites. [Ref. 13]

Thusly, all benefits to be derived from JCALS are dependent on communication, whether it be across the office, across the base, or across the country. Communications in the prototype environment are restricted to within individual sites and between prototype sites. Prototyping efforts have shown the efficacy of the JCALS communication system in this limited setting. The ability to communicate and share data between these sites and major industrial partners, as well as the ability to share data and perform local business processes in an electronic environment, is the backbone of JCALS. The system will reside on each site's local area network (LAN) and communicate over a wide area network (WAN) with the other sites, the System operational Support Center (SOSC), and industrial partners. [Ref. 15]

In MIL-HDBK-59A, the DoD notes that the telecommunications plan of CALS details an approach to the development of capabilities and telecommunications services required to support CALS activities, consistent with the phased DoD migration to Open Systems Interconnection (OSI) standards; and that the telecommunications model for CALS describes the services site processes required for a successful implementation. These services are described by modeling site configurations and interactions. [Ref. 17]

Each prototype site has developed their telecommunication systems to fit these directions. This section will refer to the PHD NSWC's examples for networks architecture.

1. Local Area Network

The JCALS prototype communicates at PHD NSWC via a LAN dedicated to JCALS traffic. The program utilizes four strands of Fiber-Optic Distributed Data Interface (FDDI) fiber-optic cables. The FDDI LAN connects five buildings in the PHD NSWC. Deployment the JCALS system will reside on the station backbone LAN and be available at approximately 142 "seats" at PHD NWSC. [Ref. 15]

2. Wide Area Network

JCALS prototype system communicates with remote sites via a Defense Information Systems Agency (DISA) Wide Area Network (WAN) (DISN). This WAN links PHD NSWC with the SOSC and the other JCALS prototype sites. JCALS at PHD NSWC is communicating with Defense Printing Service (DPS) at the Naval Construction

Battalion Center (CBC) Port Hueneme via a 56 Kbps circuit. The DISN will continue to be the WAN utilized by JCALS after deployment. [Ref. 15]

F. GLOBAL DATA MANAGEMENT SYSTEM

JCALS will be facilitated through the use of its multi-weapons systems IWSDB, Global Data Dictionary and Directory (GDD/D) services, extensive networked telecommunications, and its strict adherence to CALS and Corporate Information management (CIM) Technical Reference Model (TRM) standards. Data residing in the JCALS system, or in any system to which JCALS will interface (including JEDMICS), will be transparently available to any user with a need-to-know and proper access privileges. The system will provide uniform applications and services to implement joint functional processes through the use of the JCALS Workbench. This workbench will provide a uniform human-user interface (HUI) and will give transparent access to all data, applications, and software tools available throughout the architecture. The system, through the workbench, will provide a flexible work-flow management capability which will be tailored to suit the organizational structure of the service, command, or workplace while ensuring that future changes can be accommodated easily. [Ref. 8: p. 34]

1. Integrated Weapon Systems Database (IWSDB)

The JCALS IWSDB will provide a multi-weapons systems repository that services multiple acquisition and logistic functions. IWSDB will read, write, modify, delete, and grant application-usage permission on a need-to-know basis. Enforcement will be by a

multi-level secure (MLS) trusted computing base (TCB) rated initially at a B1 level of trust and progressing to a B3 level. JCALS will provide transparent access to technical information regardless of where it resides within the IWSDBs' distributed databases. All technical information will be strictly configuration managed. Configuration impacts due to changes will be identified by the JCALS object-oriented data management service. [Ref. 8: p. 35]

2. Global Data Management System (GDMS)

The JCALS GDMS will provide the services required to access and manage the distributed data of the IWSDB. The GDMS will respond to requests from applications or requests stored internally to JCALS to access, store, and manage data. One example of responding to requests stored internally is the production of summary data from an existing system to be stored on-line for access by system users.

The GDMS will store data in the IWSDB in a physically distributed manner. Data may be stored where the data was created, where the data will be used most frequently, or in an existing system which already contains this type of data. This will involve managing physically distributed data that may not reside in the same location as the owner/proponent of the data.

The GDMS will ensure the correctness of the user and application views and maintain the integrity of data accessed and modified. The GDD/D database will serve as a repository of data management policy and data integrity requirements for data stored in

the IWSDB. Existing systems will retain control and integrity responsibilities for their own data. The GDMS will ensure that access of existing systems data does not violate the official ownership or integrity rules of that system. The execution of an existing system's programs will be directly under the control of the existing system. [Ref. 8: p. 35]

III. CALS STANDARDS FOR INTEROPERABILITY AND INTEGRATION

A. IMPLEMENTATIONS OF THE CALS MANDATE

In August, 1988, the Deputy Secretary of Defense cited the first mandate of CALS usage for the acquisition of new weapons systems and major equipment in a memorandum to secretaries of the military department and the Defense Logistics Agency. This memorandum cited that the CALS standards would enable either digital data delivery or government access to contractor-maintained technical data bases and that, effective immediately, plans for new weapons systems and related major equipment items should include use of the CALS standards.

The CALS standards were specified for two types of systems:

- For systems now in full-scale development or production, program managers shall review specific opportunities for cost savings or quality improvements that could result from changing weapons systems' paper deliverables to digital media for delivery, or access to the data using the CALS standards.

- For systems entering development after September 1988, acquisition plans, solicitations, and related documents should require specific schedule and cost proposals for: (1) integration of contractor technical information systems and processes; (2) authorized government access to contractor data bases; (3) delivery of technical information in digital form.

This memorandum was later codified in the Defense Federal Acquisition Supplement (DFARS). DFARS tasks acquisition managers and program offices for planned acquisitions to:

- Implement CALS standards in new defense system acquisitions with CALS requirements being incorporated in the Request For Proposal (RFP) and eventually the contracts;

- Describe the extent of how the CALS standards have been implemented in their acquisition planning;

- Ensure that their offices have the sufficient computer technology infrastructure in place and are capable of receiving and managing digital data.

For weapons systems already in the DoD inventory, DFARS requires mangers to exploit the CALS standards by converting existing paper-based technical data to digital data. [Ref. 4]

On June 29, 1994, Secretary of Defense William J. Perry issued a memorandum to the Secretaries of the Military Departments and the Directors of the Defense Agencies directing that "performance specifications shall be used when purchasing new systems, major modifications, upgrades to current systems, and nondevelopmental and commercial items, for programs in any acquisition category. If it is not practicable to use a performance specification, a non-government standard shall be used." Secretary Perry allowed the use of military specifications and standards in cases where performance specifications or non-government standards are not cost effective. The memorandum went on to state that military specifications and standards listed in the DFARS, such as the CALS initiative's military specifications and standards, are no longer mandatory and should be viewed only as guidance by program mangers. [Ref. 4: p. 16]

How will the CALS effort be sustained under these conditions? As an example of how the Services balance the apparently conflicting guidance received from the Secretary of Defense in 1988 and 1994 concerning CALS implementation, the Department of the Navy (DoN) has directed its personnel on 30 September 1994 that:

> The Acquisition Plan (AP) should also include the following statement, applicable for the competitive System Dem/Val, Engineering and Manufacturing Development (EMD), Production and Deployment (P&D), and Operation and Support (O&S) efforts:

The [XYZ] project intends to implement CALS and Electronic Data Interchange (EDI) initiatives to reduce life cycle costs, improve product quality, reduce program risk and reduce the schedule of the design, development and production. The technical information required in support of the project will be made accessible through on -line contractor integrated technical information (electronic) services; physical delivery of data required for sustaining support activities will be in accordance with approved CALS format standards and specifications. For contract data requirements not evaluated as cost-effectively delivered to the CALS standards/specifications, delivery will be in mutually agreeable digital formats. The digital formats for all data users and user systems will be determined cooperatively between the government and contractor using the Government Concept of Operations (GCO), developed by the government program office, as the basis for selection.

The draft and final RFPs will incorporate requirements for the offer or to address implementation of concurrent engineering and digital delivery/electronic access of program technical information. Significant weighting will be applied to the CALS and EDI elements in source selection evaluation (not less than 10 percent of the total evaluation/rating). Offerors will be evaluated on their ability to provide integrated, shared databases environments for engineering analysis, design, manufacturing and logistic processes; and their use of CAD/CAM/CAE methods, product models/databases and simulation tools to improve product design, testing, manufacturing and support system development. The program will integrate specific program solutions with those developed by DoD/DoN infrastructure modernization initiatives and will implement, where value -effective, joint service CALS and EDI systems for the creation, management and use of digital technical information. [Ref. 11: pp. 3-3, 3-4]

B. IMPLEMENTATION GUIDELINE: MIL-HDBK-59B

The original purpose of MIL-HDBK-59 was to provide general information and detailed application guidance for contractually implementing CALS requirements in weapons systems and related equipment procurements, to those responsible for the acquisition and use of the weapons systems technical data. [Ref. 18: p. 62]

MIL-HDBK-59 (as a CALS Implementation Guide and the superseding MIL-HDBK-59A) was developed by the Department of Defense with the assistance of the military departments, Federal agencies, and industry, and is approved for use by all Departments and Agencies of the Department of Defense. It provides information and guidance for applying the CALS strategy to the acquisition, management and use of digital data in support of defense weapons systems and equipment, hereafter referred to as 'defense systems'. [Ref. 8]

This handbook provides information and guidance for applying the CALS strategy to the acquisition, management, and use of digital data in accordance with (IAW) DoD Instruction (DoDI) 5000.2. The primary focus of this handbook is the acquisition of digital data products and information services in support of defense systems. It addresses 1) CALS strategy; 2) CALS policy; 3) acquisition process guidance; 4) special considerations for existing defense systems; and 5) DoD infrastructure modernization-Joint CALS (JCALS). [Ref. 8]

MIL-HDBK-59 details a structured approach to implementing CALS requirements, data interchange standards, and data format specifications. Sections 2 and 3 provide guidance to acquisition managers on the CALS strategy and CALS policy. Section 4 provides an overview for applying the CALS strategy to the acquisition process, including development of Request for Proposal (RFP) and Statement of Work (SOW) language, detailed planning guidance for development of the CALS Government Concept of Operations (GCO), and the Contractor's Approach to CALS (CAC). Special

considerations for applying CALS to existing defense systems can be found in section 5. Infrastructure consideration issues are addressed where applicable throughout, while section 6 provides an overview of infrastructure modernization through JCALS. [Ref. 8]

C. STANDARDS FOR DOCUMENT SPECIFICATION

1. Automated Interchange of Technical Information: MIL-STD-1840B

a. Purpose

MIL-STD-1840A, Automated Interchange of Technical Information, was originally published by the U.S. Air Force on 11 September 1986. Its purpose was to standardize the digital interface between organizations necessary for the logistic support of weapons systems throughout their life cycle.

MIL-STD-1840B supersedes and enhances MIL-STD-1840A, and serves as a central standard for the CALS environment. MIL-STD-1840B standardizes formats for the exchange of digital information between organizations and/or systems to facilitate the development and logistic support of defense systems throughout their entire life cycle.

MIL-STD-1840B further refines the format of data to be exchanged in the CALS environment, the mechanisms, and parameters of those mechanisms required for the exchange to take place. Additionally, MIL-STD-1840B addresses the content of electronic product data, new packaging of data for electronic trade business transactions, and electronic product data technology.

The MIL-STD-1840B standard formally defines, by reference, the configuration and structure of data files used for the transfer and archival of technical data in digital form. It clearly defines the record formats, standardized header records, contents of the files used for exchange of data, labeling requirements during shipment, protection, packaging, and the marking of media. Some of the provisions for "protection" of media require that electromagnetically inscribed information transfer media such as encoded magnetic tapes and disks be protected against dirt, moisture, and electrostatic discharge damage during shipment. [Ref. 11]

b. Typical Applications

The MIL-STD-1840B standard is designed to be usable for all CALS-related applications where information can be prepared and received as ASCII (American Standard Code for Information Interchange) text files, product definition data files, raster image files, graphics files, or contract defined data files. This standard is not designed to be usable for specific applications, but is not restricted in any way in its application.

MIL-STD-1840B is intended for application to technical information which includes product data, product acquisition and implementation data, and product support data. Product data includes engineering drawings and specifications, as well as new and evolving digital data protocols which provide platform-independent data directly usable by a variety of unrelated computer applications. Product acquisition and implementation data

includes parameters and data necessary to manufacture and/or acquire an entire defense system. Product support information includes training and maintenance manuals, including associated illustrations, necessary to the maintenance of a defense system in a required state of readiness. The scope of this data covers the entire life cycle of a weapons system.

MIL-STD-1840B further provides general requirements for Technical Publication, Product Data, and Electrical/Electronic Application Data File document types. The Technical Publications document type includes files that contain MIL-M-28001 SGML (Standard Generalized Markup Language), Document Type Declaration with no text, FOSI (Formatting Output Specification Instance), SGML text entity, MIL-D-28000 IGES (Initial Graphics Exchange Specification), MIL-R-28002 Raster, MIL-D-28003 CGM (Computer Graphics Metafile), PDL (Page Description Language), gray scale or color illustration, or special word data. The Product Data document type includes files that represent engineering drawings in IGES or raster formats as well as numerical control manufacturing and 3-dimensional piping data files. The Electrical/Electronic Application Data Files document type includes files that contain information in the following formats: Electronic Design Interchange Format (EDIF), the Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL), IGES Electrical/Electronic application data files, and Institute for Interconnecting and Packaging Electronic Circuits (IPC).

In any typical application, the hardware and software must prepare files for transfer on the sending system by adding header information and writing files to the selected media type. Hardware and software on the receiving system must process received files by reading the files from the selected media type and stripping off the added header information. Media to be sent must also be labeled, protected, packaged, and marked appropriately prior to shipment in accordance with this standard. [Ref. 11]

c. Structure

MIL-STD-1840B is composed of the following six sections:

- **Section 1: SCOPE**. Defines the scope of MIL-STD-1840B with respect to standardizing the exchange of digital information between organizations or systems.

- **Section 2: REFERENCED DOCUMENTS**. Identifies all of the documents upon which MIL-STD-1840B is based (See Section 2.9 of this overview).

- **Section 3: DEFINITIONS.** Defines the abbreviations and terms used in MIL-STD-1840B.

- **Section 4: GENERAL REQUIREMENTS**. Specifies the general requirements of mandatory declaration files as well as the specific standards, specifications, and data formats required for data files covered by this standard (See section 2.2 of this overview).

- **Section 5: DETAILED REQUIREMENTS.** Specifies the structure, contents, media options, and packaging requirements for digital information constituting a transfer package. This section lists file naming conventions for both declaration and data files along with the header records these files require. The information required in these records include identifiers of the parent file, text files, and data files, as well as destination and source system document identifiers. Packaging requirements specified by MIL-STD-1840B include detailed instructions for labeling, protecting, marking, and packaging the transfer media for shipment.

- **Section 6: NOTES**. Provides information which is helpful, but not mandatory. [Ref. 11]

d. Advantages of Current Standard

MIL-STD-1840B, a standard for the interchange of digital technical data, is a core standard for the CALS environment. In addition to the advantage of being required for the delivery of CALS data, this standard has the advantage of having an essential function that facilitates the sharing of technical data within and among autonomous organizations.

This standard clearly defines the mechanisms for exchanging digital data with protocols defined in other CALS specifications (MIL-D-28000, MIL-M-28001, MIL-R-28002, and MIL-D-28003). The reference to and use of other standards and specifications allows this standard to evolve synchronously, as other standards and specifications evolve, taking advantage of opportunities presented by advances in current technologies, or to effectively utilize new technologies.

MIL-STD-1840B contains specific detailed instructions for using 9-track magnetic tapes as a medium for exchange of digital data. It contains flexible provisions which rely on agreements between sender and receiver for using other media such as diskettes, WORM (Write Once Read Many-times) optical disks, and CD-ROM (Compact Disk Read Only Memory) for the exchange of technical data. This reliance on agreements provides MIL-STD-1840B with the advantage of accommodating changing user needs as well as being able to adapt to new requirements and guidelines.

An additional advantage of MIL-STD-1840B is that it clearly defines the formats, standardized header records, and contents of files used for the exchange of data as well as requirements for the labeling, protection, packaging, and the marking of media during shipment. The standard also addresses electronic product data, new packaging of data for electronic trade business transactions, and electronic product data technology. [Ref. 11]

e. Vendor Support

MIL-STD-1840B has been approved for use by all agencies of the Department of Defense. It is required for the delivery of all CALS data. This military standard specifies other standards that are widely supported and accepted by national and international normalization organizations alike, providing a strong foundation for user and vendor support.

The extent of use of MIL-STD-1840B depends upon the degree of accepted implementation of the standards of interchange which it specifies. Additional information can be obtained about users and vendors who are implementing MIL-STD-1840B as a part of their implementation of these CALS standards and specifications by reviewing the same section of the summaries for MIL-M-28001 (SGML), MIL-D-28000 (IGES), MIL-R-28002 (Raster), or MIL-D-28003 (CGM). [Ref. 11]

2. Digital Representation For Communication Of Product Data: IGES Application Subsets and IGES Application Protocols (MIL-D-28000A)

The MIL-D-28000A military specification defines a standard for product definition data formats. Product definition data consists of the elements required to define a product. It includes geometry, topology, relationships, tolerances, attributes, and features necessary to define a component part or assembly of parts for the purpose of design, analysis, manufacture, test, and inspection. [Ref. 8]

a. Purpose

MIL-D-28000A is the military specification for the digital representation of product definition data using the Initial Graphics Exchange Specification (IGES) as specified by the American Society of Mechanical Engineers (ASME) standard Y14.26M (Digital Representation for Communication of Product Definition Data). MIL-D-28000A is organized into five classes by application area to meet the general delivery needs of products. [Ref. 11]

b. Application Subsets and Protocol

MIL-D-28000A specifies five classes of the IGES standard (technical illustrations, engineering drawings, electrical/electronics applications, numerical control manufacturing, and 3-D piping) as opposed to the entire IGES standard. MIL-D-28000A subdivides the IGES specification because IGES is large and complex, with different options that may be used to represent the same Computer Aided Design (CAD) model entity.

The first four classes of MIL-D-28000A specify the entities needed for specific application subsets. In this way the recipient of a MIL-D-28000A data file may specify the class of data needed without becoming an expert on the IGES. The only other entities allowed in the file are "volunteer" entities. Restrictions and specific requirements are placed on volunteer entities so that the CAD system that receives the file will not lose product information if it does not transfer the "volunteer" entities.

The four application subsets defined within MIL-D-28000A are described in the following paragraphs:

Class I: Technical Illustrations Application Subset. The Class I application subset is for the exchange of illustrations for technical publications. The emphasis is on the visual appearance of the illustrations, not on the functionality of the entities within the class. Class I is a two dimensional subset with limited, non-geometric information (such as subfigures).

Class II: Engineering Drawings Application Subset. The Class II application subset is for the exchange of product data following MIL-T-31000 (Technical Data Packages, General Specification for). The emphasis is on completeness, functionality of the drawing model, and visual equivalency for human interpretation. The class contains many geometric entities, annotation entities, and attributes such as color and line fonts, along with organizational information such as levels and subfigures. The geometric entities in this class are three dimensional, though two dimensional data can be transferred by placing all the information on the same plane within the sending CAD system.

Class III: Electrical/Electronic Applications Subset. The Class III application subset is for the exchange of product data for electrical and electronic products. The emphasis is on completeness and functionality of the model for design, manufacturing, and testing. Class III supports both the logical product representation and the physical product representation, which can both be in the same file. The logical representation includes netlists and schematics, while the physical representation includes assembly placement and pad layouts. Class III is difficult to use for unambiguous data exchange without further restrictions and interpretations applied to the subset. The IGES/PDES Organization (IPO) Electrical Applications Committee (EAC) is developing a Layered Electrical Products (LEP) AP for the representation of electrical products. The LEP AP is currently planned to be a replacement for MIL-D-28000 Class III.

Class IV: Geometry for NC Manufacturing Application Subset. The Class IV application subset is for the exchange of product data for manufacturing by numerical control. The emphasis is on the completeness and functionality of the part model. Geometry data is either 2-D wireframe, for profiles or sheet metal, or a 3-D wireframe model for multi-axis machining. Precision and accuracy on the wireframe and surface geometry must be maintained, as well as first order continuity. Geometry and Text form the majority of the data for this class. [Ref. 11]

An Application Protocol (AP) is a way to transfer defined product data through IGES. An AP documents the user requirements for an application in a graphical model called an Application Reference Model (ARM).

Class V: 3-D Piping Application Protocol. The Class V application protocol is for the exchange of product data for 3-D piping system models, but not piping drawings or internal details of equipment. The Class V AP conveys shape and location, connectivity, material characteristics, information about elements in the piping system and the piping system as a whole. The Class V provides information for the core requirements of: interference analysis, connectivity checks, basic parts lists, graphics presentation, basic piping isometrics, pipe bending instructions, and limited piping redesign. This Class V AP is not intended for general purpose CAD system, but for 3-D piping system applications only. Both the sending and receiving systems must support the specific 3-D piping system application and the Class V 3-D Piping Application Protocol for meaningful exchange. [Ref. 11]

c. Vendor Support

The IGES specification has gained support from CAD system vendors. Most CAD systems have some type of IGES translator, and even some non-CAD systems, such as Interleaf® (an electronic publications system), support the IGES specification. Support for MIL-D-28000 (i.e., the subsets) is not as widespread as support for the full IGES standard. The greatest stated support of the MIL-D-28000 subsets derives from commercial flavoring software and syntax checking software. MIL-D-28000 Class II, engineering drawings, is the most commonly supported class, followed by MIL-D-28000 Class I, technical illustrations. Presently, Intergraph has a MIL-D-28000 Class V translator under development. [Ref. 11]

3. Standardized Generalized Markup Language (SGML) MIL-M-28001B

The MIL-M-28001B specification defines a standard for preparation of textual technical information using the SGML. Data prepared in conformance to these requirements will facilitate the automated storage, retrieval, interchange, processing, and presentation of technical information from heterogeneous data sources. [Ref. 8] In essence, the CALS standard MIL-M-28001B represents the DoD implementation of the international standard ISO 8879 "Standard Generalized Markup Language (SGML)". [Ref. 11]

a. Purpose

The CALS SGML standard defines both a methodology and a high level computer language for document representation. It provides a coherent and unambiguous grammar and syntax for describing whatever objects a user chooses to identify within a document, regardless of the type of document or the nature of the document's text, and provides a formal markup procedure independent of system and output environments. [Ref. 11]

b. Document Type Definition (DTD)

Document definition of structure or content in terms of "elements", their "attributes", "entities", and other components, is a called "Document Type Definition (DTD)". A DTD defines the structure or content of a specific class of document objects.

"SGML markup" (or an "SGML document instance") consists of unformatted text with inserted SGML "tags," or tokens, which correspond to the elements and attributes of the DTD. These tags identify elements of the text (e.g., titles, paragraphs, tables, and footnotes) defined in the document's DTD. The "marked up" document (SGML document instance) can then be "parsed" using special error editing software to determine if the document's tagging conforms to the DTD. [Ref. 11]

c. *Output Specification*

In order to format an SGML source file, associated structural protocol information must be provided. This information must define formatting characteristics such as page model, font and family characteristics, point size, indenting, etc. In addition, these formatting characteristics must be responsive to certain SGML tags. For example, a "paragraph" tag may trigger a change in a line leading or a "chapter title" tag may trigger "bolding" and "center" functions within paragraphs. The Electronic Publishing Committee of the CALS Industry Standards Working Group formed a MIL-M-28001 Output Specification Ad Hoc Group to develop a standard language for providing associated formatting information for SGML instances. It was decided to use SGML itself for this purpose and provide the associated formatting information in the form of an "Output Specification" (OS) DTD. [Ref. 11]

d. Vendor Support

The vendor community is aware of the evolving nature of MIL-M-28001. Several vendors are waiting until the standard is finalized, while other vendors are undertaking full implementations. A large vendor community is represented on the Electronic Publishing Committee. For the CALS environment, vendors supporting MIL-M-28001 should not "hard-code" their systems to process only a single DTD or FOSI. Inevitably, most users will be processing a variety of technical publications which must conform to multiple DTDs and will require a system that can be configured to adapt to new and changing requirements as they arise. [Ref. 11]

4. Raster Graphics Representation In Binary Format (MIL-R-28002)

This military specification was originally conceived to fill the need for national and international standards for the storage and exchange of large engineering drawings as raster graphics files. Now known as a standardization document, its current version is based on ISO standards and the Consultative Committee for International Telegraph and Telephone (CCITT) recommendations. [Ref. 4]

a. Purpose and Applicability

The MIL-R-28002 specification establishes requirements for a standard interchange file format and raster encoding scheme for raster data. This specification identifies the requirements to be met when raster data represented in digital, binary format is delivered to the Government.

Raster graphics involves the digital processing, storage, exchange and reproduction of images. This technology supports the binary representation of a two-dimensional image as an array of picture elements, also known as pels. Each pel of the array contains information about that portion of the image. This information may include its lightness, darkness, gray-level and color. The quality of the image depends directly on the density of pels within the array, also known as resolution density or pel transmission density. High resolution density provides a high quality image, but at the expense of higher storage costs. Data compression, in which an encoding scheme is used to represent redundant data bits of information, can alleviate this storage problem to some extent. MIL-R-28002 restricts such compression to Group 4 encoding as defined in Consultative Committee on Telegraph and Telephone (CCITT) Recommendation T.6 in order to conform to developing industry standards.

MIL-R-28002 permits two types of digital representation of raster data, referred to as Type I and Type II in the specification. The Type I file format is used for raster data contained in a single monolithic block of compressed data and is called untiled raster data. The Type II file format is an Open Document Architecture (ODA) document (as specified by ISO 8613 ODA) conforming to a special application profile for raster images. Type II may be tiled raster data or may consist of a single compressed block of data as in Type I, but with all ODA parameters and data structuring included.

Type I raster data interchange is intended to be used in procuring data for systems that only utilize untiled raster data representations. Examples of such systems

include typical technical documentation systems, the Air Force Engineering Data Computer-Assisted Retrieval System (EDCARS) and the Army Digital Storage and Retrieval Engineering Data System (DSREDS). A set of graphics attributes specifying the details necessary for processing and reproducing the image must be included in a header record at the beginning of the raster file. These attributes include the size of the original image, scanning resolution, image orientation (portrait or landscape), starting position on the page, and spacing between pels and lines containing the pels. These attributes are used in reproducing the image and apply to both Type I and Type II raster data files.

Type II raster data interchange is intended to be used in procuring data for systems that need the flexibility to use tiled or a mixture of tiled and untiled raster data representations. Tiled representations are best applied in systems handling large format drawings or illustrations typically associated with engineering design. The subdivision of a drawing into tiles allows the use of only those portions of an image required at a given time by the application. This can result in reduced requirements for workstation memory and display. Attributes required for Type I are also required for Type II data and are encoded in the ODA data stream as specified by the ODA Raster DAP (as explained below). For Type II data, additional attribute information must be included to cover the size of each tile, the number of tiles in the array (image), the method of tile ordering, and the method of tile coding. This information is stored in the header record of an image file during the scanning process and is essential for reproducing the image. [Ref. 11]

b. Advantages of Current Specification

MIL-R-28002 reflects the intent of the OSD to use existing and emerging international standards as the basis for implementation. The ODA standard provides for storage of complex documents containing graphics and textual information and production of compound documents using facsimile technology. ODA was cited for Type II raster data specification in an effort to ensure that raster image data specification efforts align with evolving international raster imaging standards while promoting interoperability with other raster data formats used in the open document architecture standard. [Ref. 11]

c. Vendor Support

The Electronic Imaging/Compression Committee of the Association for Information and Image Management (AIIM) has developed a standard: ANSI/AIIM MS53 1993, the *Standard Recommended Practice - File Format for Storage and Exchange of Images - Bi-Level Image File Format: Part 1*, that specifies file formatting for exchange of bi-level, electronic images. MS53 is considered a subset of the ODA Raster DAP, but it does not allow for the tiling of raster images. This standard was developed to encourage the use of ODA by the United States image technology community and to provide a much needed standard bi-level image file format. It is seen as an introductory tool for users and implementors of ODA, ASN.1 and ODA Raster DAP applications requiring MIL-R-28002 Type II untiled data. MS53 is AIIM's attempt at a "cookbook" approach for exchanging bi-level electronic images using ODA with ASN.1 encoding.

5. Digital Representation For Communication Of Illustration Data: Computer Graphics Metafile (CGM) (MIL-D-28003)

Military specification, MIL-D-28003, "Digital Representation of Illustration Data: Computer Graphics Metafile (CGM)", specifies an application profile of the International and U.S. standards for CGM and certain specific additional requirements. The Computer Graphics Metafile standard is a published International Standard (ISO/IEC 8632), a Federal Information Processing Standard (FIPS 128), and has been adopted by the American National Standard Institute (ANSI). CGM is being developed and maintained through a coordinated effort of ISO SC24 and ANSI X3H3. U.S. and international standards are identical. [Ref. 11]

a. *Purpose and Applicability*

The overall intent of the CGM standard is to provide the lowest level of drawing functionality required to capture and reproduce a picture in a way that is portable across non-aligned applications and devices. CGM specifies two-dimensional graphics data interchange in a file format that can be created independently of device requirements and translated into formats required by specific output devices, graphics systems, and computer systems.

A metafile is a device-independent, application-independent storage format for the exchange of data that makes up a picture ("picture data"). Metafile definition in ISO/IEC 8632 includes a specification of output primitives and attributes that may be used to compose an illustration represented by an intentionally under-specified semantics

(meaning). This was done to accommodate a wide range of existing systems, and to make the standard more adaptable to the requirements of diverse applications and users. If the application software is directed to store a picture on a metafile, it has to write all of the information required for reassembly into a file. Software that performs CGM writing actions is called the "generator". Software that can read a metafile back into an application and reconstruct the intended image is called an interpreter.

A "profile" addresses implementation conformance requirements for the generator and interpreter. For generators, the graphical characteristics of the picture are mapped onto a set of CGM elements which define the images within the accuracy and latitude defined by the implementation requirements in the profile. For interpreters, the graphical characteristics of the CGM elements are rendered into a graphical image or picture within the latitude defined by the implementation requirements set forth in the profile. Without a profile, one can only address the syntactical correctness of the data stream. With a profile, one can address and test that the picture is correct. Profiles provides a way of standardizing and publicly specifying the options that a vendor supports and how they are to be supported. [Ref. 11]

b. Advantages

The CGM contains device-independent, digitally-encoded vector and raster graphics data. CGM files are easily transferred and displayed on a wide variety of hardcopy devices (dot-matrix, ink-jet, electrostatic, and laser printers, pen plotters, and film cameras). CGM files can also be easily previewed on an extensive range of softcopy

terminals. In comparison to Raster, CGM is easily modifiable, generally of much smaller size, and not dependent upon resolution of the output device. CGM compares to IGES (2-D data), CGM is faster to interpret and display, and again more compact. The selection of which of the CALS graphic standards (raster, IGES, or CGM) that best fits the application, should be the result of the thorough examination of the processes involved in the application. [Ref. 11]

c. Vendor Support

This standard associated with its Application Profile is considered a subset of the international and national CGM standard. Many vendors who claim CGM standard conformance, do not completely conform with MIL-D-28003A because of the lack of Application Profile details necessary for use with CALS applications. Currently six software vendors (Ashton-Tate, Computer Support, Lotus Development, Micrografx, Hewlett-Packard, and Software Publishing) offer applications that can import and export CGM files conforming to MIL-D-28003A. Numerous other vendors offer applications that can either import or export CGM files or can both import and export CGM files, but only in conformance with the previous version of this specification. DoD organizations planning to use a drawing application for CALS compliant illustrations should be certain that the application explicitly conforms with the import and export requirements of MIL-D-28003A. [Ref. 4]

D. STANDARDS FOR INTERNETWORKING

The resources of a single network are often inadequate to meet user's needs. Because networks that might be of interest exhibit so many differences, it is impractical to consider merging them into a single network. Rather, what is needed is the ability to interconnect various networks so that any two stations on any of the constituent networks can communicate with one another.

An interconnected set of networks may appear simply as a larger network. However, if each of the constituent networks retains its identity, special mechanisms (known as communications protocols) are needed for communicating across multiple networks. The entire configuration of internetworked networks is often referred to as an **internet**, and each of the constituent networks as a **subnetwork**. [Ref. 19: p. 471]

According to the JCALS plan, about 250 sites and contractors should communicate between each other across the internet. In the MIL-HDBK-59A, DoD described three telecommunication options in the current environment: contractor-specific network architecture, OSI compatible network architectures, and Transmission Control Protocol/Internet Protocol (TCP/IP)-based Defense Data Network (DDN) architectures. [Ref. 17: p. 177] Of these three network architectures, this section will present last two architectures as options because of their popularity and open networking capabilities.

1. Open Systems Interchange (OSI)

a. Background

OSI protocols have been developed by international standards organizations, primarily the International Organization for Standardization (ISO) and the Consultative Committee on International Telephone and Telegraph (CCITT).

As the use of computer communications and computer networking proliferate, a one-at-a-time special-purpose approach to communications software development is too costly to be acceptable. The only viable, cost-effective alternative for computer vendors is to adopt and implement a common set of conventions. For this to happen, a set of international or, at least national, standards must be promulgated by appropriate organizations. [Ref. 19: p. 436]

The International Organization for Standardization (ISO), the Consultative Committee on International Telephone and Telegraph (CCITT), and other standards formulation bodies have adopted a seven-level OSI Reference Model for guiding the development of international standards for networks of computers. It is called a "reference model" because it only recommends the functions to be performed in each of seven layers. The model does not specify detailed standards for each layer. Those are left up to individual standards bodies in adopting countries. [Ref. 20: p. 188]

The term Open Systems Interconnection (OSI) qualifies for the exchange of information among systems that are "open" to one another for this purpose by virtue of their mutual use of the applicable standards. Hwever, the fact that a system is open does

not imply any particular systems implementation, technology, or means of interconnection, but refers to the mutual recognition and support of applicable standards. [Ref. 19: p. 436]

b. Concepts

A widely accepted structuring technique, and the one chosen by ISO, is "layering." Communications functions are partitioned into a vertical set of layers. Each layer performs a related subset of functions required to communicate with another system. Layering relies on the next lower layer to perform increasingly more primitive functions and to conceal the details of those functions. At the same time, it provides services to the next higher layer. Ideally, layers should be defined so that changes in one layer do not require changes in preceding or succeeding layers. Thus we have decomposed one problem into a number of localized, more manageable subproblems.

The task of the ISO subcommittee was to define a set of layers and the services to be performed by each layer. The partitioning should group functions logically, should have enough layers to make each layer manageably small, but should not have so many layers that the processing overhead imposed by the aggregation of layers is burdensome.

The attractiveness of the OSI approach is that it promises to solve the heterogeneous computer communications problem. Two systems, no matter how different, should be able to communicate effectively if they have the following in common:

- They implement the same set of communications functions.

- These functions are organized into the same set of layers. Peer layers must provide the same functions, but note that it is not necessary that they provide them in the same way.

- Peer layers must share a common protocol.

The OSI model, by defining a seven-layer architecture, provide a framework for defining these standards. [Ref. 19: pp. 437-441]

c. *OSI in the CALS*

OSI compatibility, the telecommunications technology that industry as well as government is moving rapidly to implement, is cited as one of the options for CALS telecommunications in MIL-HDBK-59A. Federal Information Processing Standards Standard Number 146 (FIPS 146) adopts the Government Open Systems Interconnection Profile (GOSIP) Version 1 for government use. GOSIP defines a common set of data communications protocols which enable computer systems developed by different vendors to interoperate and exchange data. GOSIP version 1 includes requisite information for acquisition of the OSI FTAM (File Transfer and Access Management) and VT (Virtual Terminal) applications as well as the various lower layers of protocol to support them. This suite of communications protocols include the most popular physical media including token ring, broadband, and Ethernet. [Ref. 17: pp. 178]

MIL-HDBK-59A emphasis also that OSI should be the sole, mandatory, interoperable protocol suite for new procurements involving new Automated Information Systems (AISs) or major upgrades to existing AISs, including network services.

2. TCP/IP-based DDN

a. TCP/IP Background

Despite of predating of TCP/IP from OSI and far more implementation and practical experience, little attention has been given to TCP/IP. TCP/IP is an outgrowth of the development of Advanced Research Project Agency computer NETwork (ARPANET) and the Defense Data Network. Whereas the OSI architecture is intended to guide the future development of protocols, it is the experience already gained in the development and use of protocols within ARPANET that has led to this communications architecture.

Both OSI and TCP/IP deal with communications among heterogeneous computers. Both are based on the concept of communications-specific protocol architectures and have many similarities. However, there are philosophical and practical differences between the OSI model and the TCP/IP model. [Ref. 19: p. 451]

b. Characteristics

The DoD has issued standards for a set of communications protocols. Its motivations are similar to those of the ISO and many other computer systems customers. DoD needs to have efficient, cost-effective communications among heterogeneous computers. There are three reasons why the DoD has chosen to develop its own protocols and architectures rather than adopt evolving international standards. These are explained as follows: 1) The DoD protocols were specified and have enjoyed extensive use prior to ISO standardization of alternative protocols. Because, at the time of creation, the DoD

needs were immediate, it was deemed impractical to wait for the ISO protocols to evolve and stabilize. 2) DoD-specific communications requirements have a major impact on the design of industry-accepted protocols and architectures. These concerns have not been uppermost in the minds of the ISO developers, and predictably are not reflected in the OSI model. 3) Philosophic differences exist between perceived DoD and industry requirements concerning the appropriate nature of communications architectures and protocols. [Ref. 19: p. 451]

The first reason is self-explanatory. The second reason is the specific DoD requirements, many of which are also relevant in other contexts, such as survivability, and include availability, security, network interoperability, and the ability to handle surge traffic. The third reason is best explained by examining the differences between TCP/IP and the OSI model. There are four fundamental differences:

1) **The concept of hierarchy versus layering**. The TCP/IP protocol recognizes that the task of communications is too complex and too diverse to be accomplished by a single unit. Therefore, the task is broken up into modules or entities that may communicate with peers in another system. One entity within a system provides services to other entities and, in turn, utilizes the services of other entities. The OSI model is based on similar reasoning, but takes it one step further. The next step is recognition of protocols at the same level of the hierarchy that have certain features in common. This yields the concept of rows, or layers, and the attempt to describe in an abstract fashion which features are held in common by the protocols within a given row.

2) The importance of internetworking. A historical difference between the TCP/IP and OSI models is the importance that TCP/IP places on internetworking. Internetworking occurs when two communicating systems do not attach to the same network. Thus transferred data must traverse at least two networks, usually through an interface router known as a "gateway." Both the initiating and receiving networks may be quite dissimilar. The requirement for internetworking has led to the development of an Internet Protocol. Such a protocol was not originally given a place within the OSI model. The current OSI document makes brief reference to the possibility of networks in tandem, and an internet protocol has emerged as sublayer of the network layer (layer 3). This is not a clean solution, but it is not the only one possible within the seven-layer architecture.

3) The utility of connectionless services. A connectionless service is one in which data are transferred from one entity to another without the prior mutual construction of a connection. TCP/IP places equal importance on connectionless and connection-oriented services, whereas the OSI model is couched solely in terms of connection-oriented services. It is expected, however, that further versions of the OSI model will incorporate connectionless services.

4) The approach to management functions. A final difference between the TCP/IP and OSI models is the way in which various management-related functions are treated.

The concept of management functions seem not to meld well with the OSI model, partly because these are mostly connectionless services, partly because there is no

"place" for them. TCP/IP does not preclude this approach, rather it goes further. Within this architecture, a uniform approach is taken to many of these functions and they are provided by protocols that can best be described as "session layer" protocols. This description reflects the fact that these protocols make use of transport services. [Ref. 19: pp. 451-454]

c. Architecture

The TCP/IP architecture is based on a view of communication that involves three agents : processes, hosts, and networks. Processes are the fundamental entities that communicate between initiators and recipients. Processes execute on hosts, which can often support multiple simultaneous processes. Communication between processes takes place across networks to which the hosts are attached. These three concepts yield a fundamental principle of TCP/IP: the transfer of information to a process can be accomplished by first getting it to the host in which the process resides and then getting it to the process within the host. With this in mind, the DPA organizes TCP/IP protocols into four layers:

- The network access layer contains those protocols that provide access to a communication network. Protocols at this layer exist between a communications node and an attached host or its logical equivalent.
- The internet layer consists of procedures required to allow data to traverse multiple networks between hosts.
- The host-host layer contains protocol entities with the ability to deliver data between two processes on different host computers.

- The process/application layer contains protocols for resource sharing (e.g., computer-to-computer) and remote access (e.g., terminal-to-computer). [Ref. 19: pp. 455-456]

d. DDN in CALS

DDN is mentioned as a CALS telecommunication option in the MIL-HDBK-59A. Because the DDN is a DoD network, sized to support defense requirements within available funding, the acquisition manager must provide sponsorship for defense contractor nodes, and must satisfy defense Communications Agency requirements to justify and schedule connection to the network. The DDN is currently based on TCP/IP standards which are widely supported in government and industry with many commercial, off-the-shelf products. However, the DoD has committed to accompany industry in it's transition to Open System Interconnection (OSI) compatible products, implemented through new standards such as the Government OSI profile (GOSIP). [Ref. 17: pp. 178]

E. EC/EDI

1. Background

The concept of EC/EDI started over 30 years ago. During the 1960s, the Transportation Data Coordinating Committee (TDCC) of the United States became concerned about the strangling effect of paperwork on the transportation industry. In 1975, the TDCC published the first set of rules for EDI, many of which still apply. At that

time, computer hardware, software, and networks were not capable of supporting these new business procedures. In 1979, the American National Standards Institute (ANSI) approved TDCC's approach to EDI access and use, as embodied in the ANSI X12 standard. Since then, the ANSI X12 committee has generated over 20 cross-industry transaction data format variations on the basic theme to accommodate unique situations in diverse business areas. [Ref. 21: p. 3]

2. Definitions

Electronic Data Interchange (EDI) is the intercompany, computer-to-computer exchange of business documents in standard electronic data formats. Transaction data is transmitted from the sending company's application to the receiving company's application without human intervention. Transactions (also called transaction sets) include invoices, shipping schedules, advance ship notices, court filings, bills of lading, and purchase orders. These are transformed to a standard data format and electronically transferred between trading partners without utilizing hard-copy or re-keying information. Standard transaction sets are approved by ANSI in the X12 standard. [Ref. 21: p. 3]

Electronic Commerce (EC) includes EDI, but recognizes the need for inter-personal (human-to-human) communications. Of the transfer activities that aid in communications technologies, EC is significantly broader than EDI. [Ref. 22: p. 7] EDI is the primary technology for achieving EC. EC also may include electronic mail (E-mail), electronic bulletin boards (BBS), electronic funds transfer (EFT), and similar technologies.

EC is used to reduce paperwork, communicate faster, reduce errors, reduce data entry costs, strengthen trading partner relationships, and lead to more effective decision making. [Ref. 2: p. 37]

3. EC/EDI in the Government/DoD

In 1993, the President of the Unites States signed a memorandum directing the Federal Agencies to actively pursue streamlining of the procurement process through the implementation of Electronic Commerce (EC), a forum successfully used by large and small businesses alike for a number of years. In the memorandum, the President noted that moving to an Electronic Commerce (EC) system to simplify and streamline the acquisition process will promote customer service and cost-effectiveness. The electronic exchange of acquisition information between private sector and Federal government agencies (i.e., the use of EC) will increase competition. It will do so by improving access to Federal contracting opportunities for the more than 300,000 suppliers currently doing business with the Federal government. Enhanced opportunities would be, through this mechanism, provided for small businesses and many other suppliers who find access to bidding opportunities difficult under the current system. To these ends, the President set forth the following objectives for EC:

- Exchange of acquisition information electronically between the private sector and the Federal government to the maximum extent practicable.
- Provide businesses, including small, disadvantaged, and women-owned businesses, with greater access to Federal acquisition opportunities.

- Ensure potential suppliers are provided simplified access to the Federal government's EC system. Employ nationally and internationally recognized data formats that serve to broaden and ease the interchange of data.
- Use agency and industry systems and networks to enable the government and suppliers to exchange information and access Federal acquisition data. [Ref 23: pp. 45-46]

The task of developing the architecture and overseeing implementation of EC was assigned to the Electronic Commerce Task Force under the President's Management Council (PMC). In order to complete the task of the President's memorandum, the task force chartered a Federal Electronic Commerce Acquisition Team (ECAT) and directed it to develop a comprehensive plan for implementing an EC capability. [Ref. 23: p. 46] ECAT recognized that the proliferation of implementation conventions is a major stumbling block in the use of EDI as the foundation of EC, and recommended the development of Federal Implementation Conventions. [Ref. 24: p. IT-198]

4. Standards for EDI Implementation Convention

There are two worldwide known standards for EDI: X12 and United Nations/Electronic Data Interchnage For Administration, Commerce, and Transport (UN/EDIFACT). In 1979, ANSI chartered X12, Electronic Data Interchange, to develop uniform standards for electronic interchange of business transactions. It was formed by joining together two industry standards groups that had been developing EDI standards since the late 1960s, and that had foundation documents to draw from immediately.

The history of EDIFACT is relatively brief. The United Nations Working Party 4 on Facilitation of International Trade Procedures began its work on international

EDIFACT standards a decade later, and did not adopt its first message until 1987. During the 1990's rush to a global marketplace, the European Community 92's lifted European trade restrictions, and the heavy use of EDI for customs clearance in the Pacific Rim countries and New Zealand make international EDI standards a business imperative. This has caused UN/EDIFACT to grow swiftly. [Ref. 25: p. 55]

In spite of the late starting of UN/EDIFACT standards, worldwide adoption of these standards as the basis for international exchange of computer-processable business, including product data, is resulting in a rapidly multiplying set of competitive commercial networks, products, and services to implement UN/EDIFACT-based EDI.

At the American National Standards Institute (ANSI), Accredited Standards Committee (ASC), June 1993 meeting, the ASC X12 organization formalized its intention to migrate its standards to alignment with UN/EDIFACT. X12 voted to adopt UN/EDIFACT as a single standard after the release of Version 4 of the X12 American National standards, which is expected in 1997. The release of Version 4 is seen as the logical beginning for migration of X12 to UN/EDIFACT.

The recent ASC X12 decision to migrate to UN/EDIFACT underscores the emerging importance of these international standards. [Ref. 25: p. 54]

5. EDI on the Internet

EDI, by definition, includes the direct transmission of data between firms, transmission using an intermediary such as a value-added communication network (VAN)

or bank, and the exchange of computer tapes, disks, or other storage devices between locations. [Ref. 26]

There is an easy way to access and use EDI: the Internet. The Internet is the inter-connection and synergism of existing, connected corporate and government networks utilizing commonly used telecommunications standards. [Ref. 22: p. 6] The Internet can be used to do business just like using telephone (and many times it is accessed through dial-up protocols). The same Internet connection an organization uses to send electronic mail could also be used to send EDI transactions.

There are benefits for EDI from Internet:

- Adoption of common standards and proven inter-operable systems.
- Adoption and deployment of a distributed Directory Service capability, so that one can readily contact, electronically, any other organization in the world.
- Explicit commitment by participating organizations to cooperatively route traffic, work to resolve addresses, and meet required standards.
- Layering of applications (such as EDI) over existing, proven applications.
- A standards process with reference implementations which all vendors have equal access.
- Widely available public domain software including, but not limited to, applications, ptotocol/transports and multiple platform development tools. [Ref. 21: pp. 7-8]

While EC/EDI will certainly improve the internal communications and business processes of individual enterprises with the above mentioned benefits, the real payback comes when EC is implemented on an inter-enterprise basis. It is the inter-enterprise

world in which security needs become most obvious, beginning with authentication and non-repudiation, and continuing into privacy through encryption. [Ref. 27: p. 24]

As the methods for them, Ellingen mentioned some of the details in his article; For EDI authentication and non-repudiation: the digital signature[1] based on HyperText Transfer Protocol (HTTP)[2] Security; and privacy; public key encryption.

EC/EDI are bringing major changes to the world of business domestically and internationally. It is fitting that the largest international network, the Internet, should be coming into greater use. Furthermore, secure EDI over Internet is available now. [Ref. 27: p. 26]

F. CITIS : MIL-STD-974

1. Introduction

The Contractor Integrated Technical Information Service (CITIS) is a contractor -developed and maintained service providing electronic access and/or delivery of government-procured contractually required information. CITIS is generally acquired from prime contractors who may also use electronic networks for access and delivery of information from their suppliers. Thus, the prime contractor is the information integrator for a specific program/product acquisition. The ultimate goal of CITIS and CALS, in

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[1] A digital signature contains two components: 1) An undeniable statement of the identity of the person who signed the document; 2) A unique mathematically-computed number, or "fingerprint" of the document which is signed. [Ref. 27, p. 25]

[2] A protocol used in the World Wide Web (WWW) technology which will be the basis of may CommerceNet applications. [Ref. 27, p. 24]

general, is to reduce lead times and costs for weapons systems design, manufacturing, and support processes, and at the same time assure technical information accuracy and timeliness. Figure 3-1 compares current, typical business practices with the program operation in the CITIS environment. [Ref. 11: p. (7)-3]

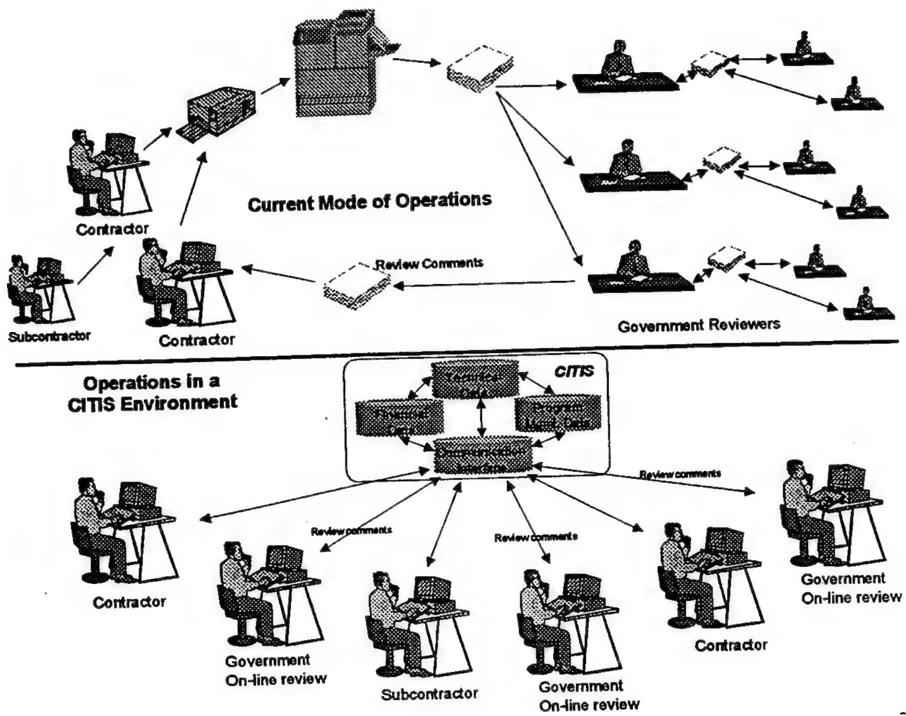

Figure 3-1. Current Operating Environment vs. CITIS Environment [Ref. 11: p. (7)-4]

2. Purpose of CITIS Requirements

This standard is designed to be incorporated into a contract to define the functional requirements for a computer-based service to provide access to information. CITIS is intended to be an efficient, contractually implementable means for providing the

government with on-line access to contractor generated data and Government Furnished Information (GFI) and the electronic transfer of such data. Ultimately, CITIS will replace most, if not all, contractor delivery of hard copy information currently required by the government throughout a programs life-cycle. The requirements are specified in terms of information services and functions which must be selected to meet the needs of each DoD acquisition program. [Ref. 28: p. 12]

The U.S. government encourages industry to utilize a high degree of information integration across the enterprise and among business partners. However, information integration capabilities are evolving within industry and, as each CITIS application is initiated, it will be necessary to establish baseline integration requirements and allow for improved integration as the program progresses and new technologies become available. Therefore, the process to select specific functions and standards must be coordinated with contractors and government users throughout the program life cycle. [Ref. 28: p. 12]

3. Relationship of JCALS and CITIS.

The government infrastructure being developed and the CITIS are viewed as complementary concepts. The JCALS system provides the preferred government gateway to contractor enterprises. The use of JCALS provides a known set of interface parameters (i.e., data elements, Global Data Dictionary and Directory (GDD/D), interface protocols, etc.). This will allow acquisition managers to easily construct "Government Concept of

Operations" (GCO) for their programs that will provide consistent and cost-effective solutions over the defense system life-cycle. [Ref. 8: p. 35]

JCALS system specifications indicate the following four options for bi-directional CITIS interface (see Figure 3-2): 1) non-interactive data exchange using removable digital media; 2) selected CITIS functions using dial-up or network access capabilities; 3) on-line interface where data dictionaries are mapped to each other for transparent, seamless access; and 4) fully integrated, JCALS site-type interface for which the contractor is furnished GDD/D services, software and, if required, equipment (dependent on the infrastructure already in place at the contractor's site).

As the JCALS system evolves, the acquisition manager should consider implementing the fourth option of JCALS/CITIS interface as the most assured methodology of achieving compatibility. However, if the cost-effectiveness of this strategy is prohibitive, then providing the contractor with compatibility guidance to achieve the third option of JCALS/CITIS interface is recommended. Either strategy will ensure that the interface is streamlined and standardized; minimize the problems incurred by an acquisition manager requiring access to multiple CITIS systems; provide for easier technical information download/transition to JCALS; and ensure the uniformity of software tools. Option 3's interface is achievable through adherence to the compatibility standards in Appendix A which are based on the TRM and CALS standards. Most important of these standards are the data dictionary standards. JCALS is in the process of submitting data elements for standardization through its Functional Data Administrator

(FDA) and Defense Information Systems Agency (DISA). These data elements will be documented in the JCALS data model and its Data Element Dictionary. Options 1 and 2 represent the least sophisticated types of CITIS connection, and have several inherent drawbacks (among them are potential delays in receiving timely technical information). Acquisition managers should determine which CITIS options will be implemented based on a business case analysis to be documented in the GCOs for their programs. [Ref. 8: p. 37]

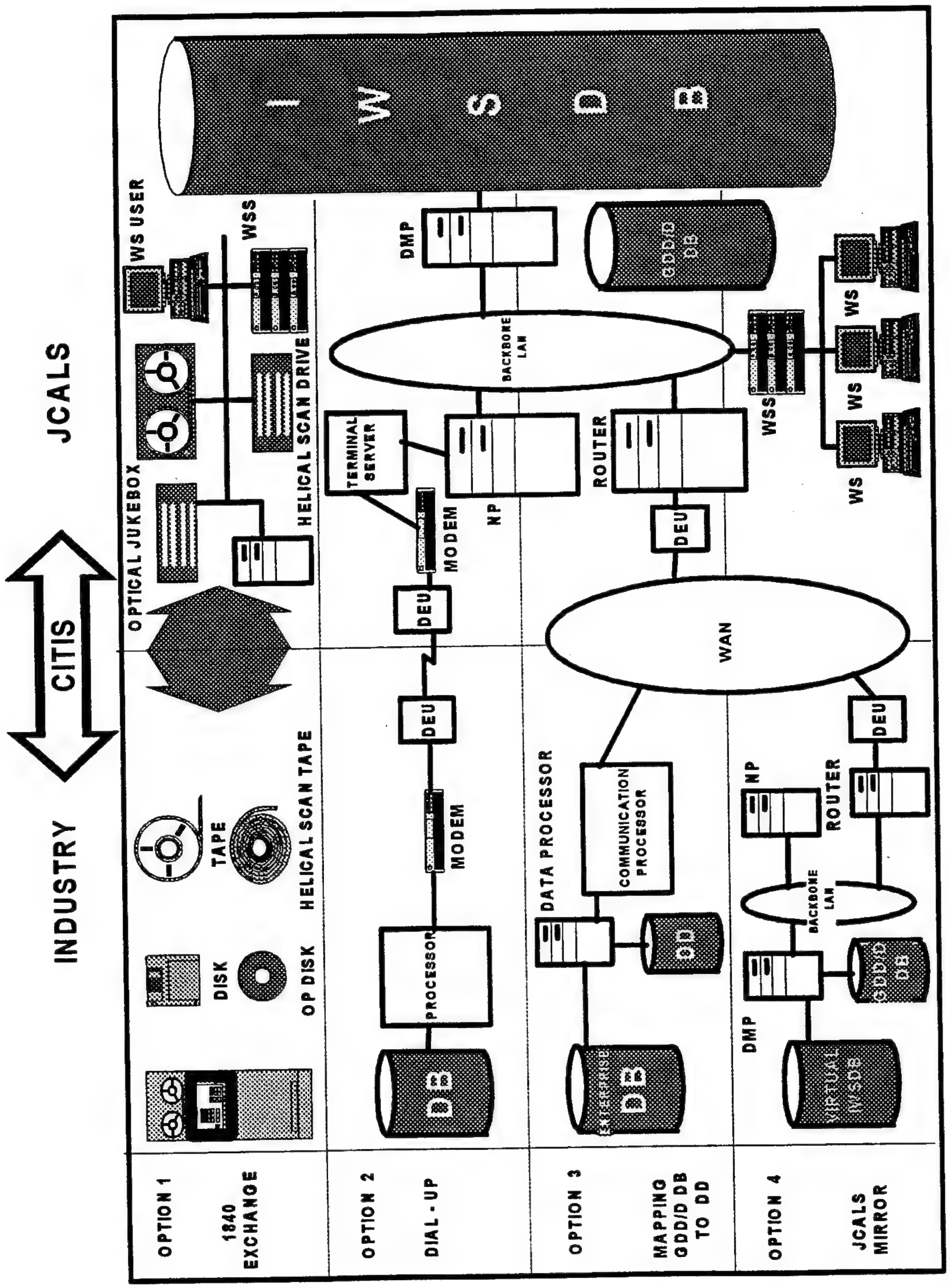

Figure 3-2. JCALS/CITIS Interface Levels. [Ref. 8, p. 38]

IV. APPLICATION FOCUS AREA

In the JCALS world program, only the TM/TO functionality has been validated on a joint service basis. The Army Strategic Logistics Agency is now coordinating with the Services to reach agreements on other functionalities. It appears that in the near future Logistic Support Analysis and Engineering Change Proposals, among others, will be added to the program. [Ref. 13] This chapter will present some examples of those areas. TM functionality is almost done and DoN described it in the *Navy/Marine Corps Manager's Desktop Guide for CALS Implementation* .

A. TECHNICAL MANUAL

The first target of the JCALS is the hard copy Technical Manuals (TMs) or Technical Orders (TOs). PM JCALS is developing techniques through which to digitally manage, acquire and improve these documents and produce digitally reproducible masters. From the example of PHD NSWC, Technical Manual development and publishing is the only logistic functional element currently available on JCALS.

1. Introduction

Technical Manuals (TM) are publications that contain instructions for the installation, operation, maintenance, and support of defense systems, defense system components, and support equipment. The digital environment for the creation, management, and use of TMs based on CALS standards is essentail for transitioning from

paper-intensive defense system acquisition and support processes to automated and integrated digital processes.

The Department of Defense (DoD) CALS strategy is designed to promote the digital creation, management, and use of data in the acquisition and support of DoD systems. CALS is not a single system, but rather a philosophy that emphasizes process improvement and the application of information technology to those processes for the purpose of digital sharing of data. This includes the data generated by the processes required to develop and maintain the TMs. One goal of CALS is to maximize the reuse of data throughout the product life cycle. An effective way to meet this goal is to design and implement processes that are supported by computer tools. The computer tools create reusable data that can be exchanged electronically to optimize the process. The CALS strategy encourages well defined processes that use computer tools for enterprise integration. Information architectures based on CALS strategies enable contractors, customers, and government agencies to share data, in real time, to design, develop, manufacture, distribute, and service products. Processes and computer tools, following CALS strategies and information technologies, reduce time-to-market and cost, and increase quality and performance. [Ref. 11, p 10-5]

2. General Considerations

The development of a CALS strategy for TMs needs to be carefully examined to maximize the value for a specific defense system program. Program attributes such as

technology, costs, quantities, and schedules have a profound effect on the delivery requirements for TMs. The technical data Logistic Element Manger (LEM) must consider the life cycle of the procurement and the infrastructure in place or being developed to support the TMs for their program.

TMs are any technical publication or other form of media used to install, operate, maintain, test, repair, overhaul, or provide logistic support of ships, aircraft, defense systems, or defense material. TM data may be presented or delivered in any media including, but not limited to, hard copy, audio and visual displays, on-line access, magnetic tape, discs, and other electronic devices. [Ref. 11, p 10-10]

a. Identify/Establish the Requirement for the TM

The technical data LEM will first identify the requirement to procure a TM through the development of overall supportability goals and the initial maintenance philosophy. This is brought about through the Logistic Support Analysis (LSA) process. The LSA process will quantify and define requirements such as the need to operate or perform maintenance on equipment. The Logistic Support Analysis Record (LSAR) will contain the necessary task narratives for the operation and maintenance of equipment and will be used as the primary source for the development of technical manuals of various types. [Ref. 11, p 10-12]

b. Identifying the TM User's Requirements

The technical data LEM must now identify the intended TM user's infrastructure. The users include those involved in system acquisition, review, and approval, the TM management infrastructure and the end user. The technical data LEM should consider the existing and planned infrastructures for both government and contractor facilities; available CALS data exchange standards; and the various digital data deliverable options in terms of media, format, and access. Documentation of this infrastructure review will take the form of a Government Concept of Operations (GCO), and will include: 1) the hardware and software systems the Government has, or is developing, to manage and use the data; 2) data users, types of data, frequency of use, and timeliness of data access or delivery to each user; 3) data use and the review and/or approval processes to support life cycle functions; 4) users' locations and their primary functions in support of the defense system; 5) data interchange requirements including format, media, applicable standards, and existing telecommunications capabilities; 6) access authorizations and restrictions; 7) data acceptance requirements including data format and content of data and the government process for accepting product, processable, or Contractor Integrated Technical Information Service (CITIS) data; and 8) digital data resources or source data (libraries of historical data, standards, and specifications) available to support program acquisition and logistics processes.

Acquisition requirements for user hardware and software to support a fielded defense system are normally under the funding discretion of the technical data

LEM and must be considered during the CALS implementation strategy and planning process. [Ref. 11, p 10-12]

c. *TMs in the CALS Environment*

The technical data LEM should be aware that it is possible to acquire TMs in a variety of forms depending upon the needs of the users. Documents such as maintenance manuals may be highly beneficial when procured as Interactive Electronic TMs (IETM). The IETM user would be the technician whose main concern is finding the desired maintenance-related information quickly and easily without being burdened in the field with the entire maintenance manual. Description, operation, and maintenance, and installation and checkout manuals, however, may be procured best in raster or Page Description Language (PDL) since these manuals are not used as often. Obviously, it is better to leave these decisions up to the individual program office since each defense system program is unique in its requirements.

Primary considerations for the technical data LEM to address when applying CALS to the creation, management, and use of TMs is the media, format, and content of TM data deliverables and their respective end users.

Paper, microfiche, and microfilm have been included in this discussion of CALS because much of the TM inventory is still available on these media. The benefits associated with using digital data far exceed the costs. For TMs some benefits of digital data include: (1) improved handling and reduced storage of TM data with electronic filing

and archiving; (2) reduced costs associated with printing and distributing TMs by providing on-line access to the TM data, so that personnel could access the data repository from their field activity and view and/or print the specific TMs they require; and (3) improved accuracy and timeliness of the TM data, due in part to the simplified incorporation of change pages. [Ref. 11, p 10-14]

3. Life Cycle Considerations

TMs are generally not required until the later acquisition life-cycle phases of a defense system program. TMs available during the earlier phases may be preliminary copies that have not been verified or have not received final acceptance but are useful for test verification, training, and operation. Final Reproducible Copies (FRC) are available in the later phases. The technical data LEM must consider the information volume and typical use of the data generated during each of these phases to determine the appropriate TM deliverable format. Note that the deliverable format may be different for each phase (e.g., preliminary versions delivered in mutually-agreeable word-processing format and FRCs in SGML format). [Ref. 11, p 10-16]

4. Contract Data Requirements Lists (CDRLs)

Delivery of defense system data in digital form requires changes to the solicitations and contracts including their attachments and enclosures. These changes should be made with full consideration of the ability of defense activities to make cost effective use of digital data deliverables or access. Each defense system program may include unique

requirements for which additional program-specific tailoring will be needed. Most of the applicable CALS standards and specifications contain contract-negotiable options from which the technical data LEM must choose to satisfy program-specific requirements including multiple classes or types of data formats.

The TM Contract Requirements (TMCR) will identify the types of TMs required and include language that specifies exactly how data will be delivered (including media, format, and content) under the contract. CALS standards should be invoked whenever possible for digital delivery of support products such as engineering drawings and TMs. The media for delivery such as magnetic tape, optical disk, or on-line (networks, telephone modems, CITIS) should be compatible with Government receiving system capabilities. Some digital deliverables, especially interim deliverables, may be efficiently acquired by agreeing on a common word processing package in the contract and specifying the appropriate and compatible physical media such as magnetic disk, magnetic tape, etc. [Ref. 11, p 10-16]

5. Interactive Electronic TM (IETM)

An IETM is a computer-based collection of information needed for the diagnosis and maintenance of a defense system. It is optically arranged and formatted for interactive presentation to the end user on an electronic display system. Unlike other optical systems that display a page of text from a single document, IETMs present interrelated information from multiple sources tailored to user queries.

Specifications for defining IETMs include:

- MIL-D-87269, *Database, Revisable:* Interactive Electronic Technical Manuals, for the Support of
- MIL-M-87268, *Manuals, Interactive Electronic Technical:* General Content, Style, Format, and User-Interaction Requirements
- MIL-Q-87270, *Quality Assurance Program:* Interactive Electronic Technical Manuals and Associated Technical Information; Requirements for

An IETM is essentially a hypertext document, which consists of a collection of "interconnected writings." These interconnections allow a user to browse through a document by selecting points of interest or hot spots that may be connected to other related text, hot spots, or menus. The user could then continue to follow along these "paths" to other cross-referenced points in that collection of writings. This creates a "pageless" document that, depending on the source database, can contain a collection of information from a variety of sources. Also, rather than limiting these documents to pure text, we may incorporate graphics, audio, video, and/or computer programs into the content of the document, creating what is known as a hypermedia document.

By streamlining access to the desired information and by providing multiple paths to other related information, the IETM offers a more efficient and more comprehensive method of using technical information. Unrestricted by the page-oriented display and the use of sole-source information, the IETM duplicates on the Personal Computer (PC), the research environment available in a well-equipped multimedia library; displays only the actions appropriate for resolving a specific problem; provides fault-isolation tables and diagrams; and guides the technician through the troubleshooting process via a user-friendly query method. IETMs permit the user to locate information more easily and

to present it faster and more comprehensively in a form that requires much less storage than paper. [Ref. 11, p 10-22]

a. *IETM Viability*

The technical data LEM should consider whether the TM will ultimately be used in an interactive computer environment, the IETM. The IETM format offers the user distinct advantages over the traditional TM. Some IETM benefits include: 1) reduction in the false removal rate of Line Replaceable Units (LRU) or Weapon Replaceable Assemblies (WRA); 2) reduction in troubleshooting time; 3) reduction in the TM support costs associated with distribution, management, and storage; and 4) allowing training activities to concentrate more on generalized training versus system specific training. The technical data LEM should first determine whether the end item or defense system program is currently in the early phases of design, whether the life cycle requirements for the TM exceed five years, and whether the Technical Data Package (TDP) or LSAR database contains, or can be economically altered to include, a numbering system similar to MIL-STD-1808. If any of these considerations can be answered "NO," then an IETM is not recommended. If all considerations can be answered "YES," then a business case analysis should be performed to determine the economic feasibility of the IETM. If results from this analysis recommend pursuing an IETM or quality readiness and/or support factors lend adequate credence to the need for an IETM, development of an IETM should be pursued. In this case, develop IETM. [Ref. 11, p 10-23]

b. IETM Development

Once IETM development has been decided, the technical data LEM must first determine whether this effort will be associated with an existing IETM in terms of either the modification of an existing IETM or the creation of a supplement to an existing IETM. If this is indeed the case, then the technical data LEM must determine whether an existing infrastructure and display device will be used in conjunction with the IETM and whether this infrastructure uses a proprietary format. If all of the above conditions are true, then the final IETM developed should remain in the existing proprietary format. However, if any of these conditions is not met, then it is advised that the IETM be developed using the new IETM standards. [Ref. 11, p 10-24]

B. LOGISTICS SUPPORT ANALYSIS (LSA)

This section presents about LSA. LSA has not been validated by all joint services yet. But it has been tested in prototype sites. The Army Strategic Logistics Agency is coordinating with the Services to reach agreement on this functionality. Followings are from the Guide of DoN.

1. Introduction

Logistics Support Analysis (LSA) is a systematic and comprehensive analytical process that is conducted on an iterative basis through all life cycle phases of the system/equipment. LSA is for quantifying and measuring supportability objectives

(supportability includes all elements of Integrated Logistics Support (ILS) required to operate and maintain the system/equipment.) Depending on the level of tailoring, extensive amounts of information and data are required as an input to, and generated as a result of, the LSA process. The LSA process fits into the ILS process as LSA tasks are planned, initial front end analyses are performed, and LSA information is generated.

LSA information consists of all data resulting from the analysis tasks conducted as defined in MIL-STD-1388-1A and is intended to be the primary source of validated, integrated, design-related product support information pertaining to an acquisition program. LSA information is developed and maintained as a result of design, support, and operational concept development and is updated to reflect changes.

LSA Record (LSAR) data is a subset of LSA information and is a structured means of aggregating LSA data. It is available for use by all services and ILS element functional areas. Because each element of LSAR data is defined and has a specified data structure, the LSAR has evolved as the primary means of storing logistic support data in digital media. [Ref. 11, p 11-5]

2. CALS and LSA by Functional Activity

Considerations that must be addressed when an Acquisition Manager is acquiring LSA data in digital format include: 1) specifically who will use the data?; 2) what hardware and software are needed to use it?; 3) will the digital data be applied directly or as source information for the follow-on products?; and 4) are there digital data sources available that can be used as input to the LSA process if source data is available, who has

it, what form is it in, and are there any challenges associated with providing it? These considerations, to various degrees, must be addressed by the Acquisition Manager for and within each of the three major activities (create, manage, and use) associated with LSA data acquisition. [Ref. 11, p 11-7]

3. Current Considerations for the LSA Process in a CALS Environment

The four prime factors that govern system acquisition programs are cost, schedule, performance, and supportability. The LSA process provides direct input into the supportability and cost factors associated with a system/equipment and, therefore, provides significant input into system/equipment decisions. The CALS environment offers the opportunity through digital application of the LSA process for reductions in Life Cycle Cost (LCC). The ability to create data once (including LSA, engineering, and ILS data) and use it many times impacts the cost of the LSA process and the follow-on support costs. If the LSA data and associated analyses (FMECA, RCM, etc.) are created in a digital format, then digital data required for the LSA can be linked and fed to the LSAR database in an automated fashion. The initially created LSA data is then available for use in all technical data products. The Acquisition Manager must consider the digital format, media, HW/SW issues, required framework, architecture, and Government infrastructure when developing the Government Concept of Operations (GCO) concurrently with selecting LSA tasks. [Ref. 15, p 11-16]

4. Future Considerations for the LSA Process in a CALS Environment

This paragraph will present some thoughts on where CALS is headed and how that might affect data use in the future. The influence of infrastructure developments in the Navy, within the DoD, and even in the international community will all affect the potential environment in which the LSA data acquired now may have to be used in the future. [Ref. 11, p 11-25]

a. Integrated Weapon Systems Database (IWSDB)

Future trends must lead to and support the fundamental objective of CALS, which is to lower costs to the Government, improve quality, and shorten lead times. The electronic sharing of data allows it to be created once and then used by multiple users, multiple times. The integration of functional processes will start with the integration of data. The acquisition strategy must specifically address the automation and integration of technical information systems and functional processes.

The process for determining LSA data and LSAR database requirements is an extension of the process currently used for determining data requirements, selecting appropriate data items, and developing the Contract Data Requirements List (CDRL) that identifies the requirements. The LSA/LSAR databases are the building blocks that are necessary to support an IWSDB. The process for determining LSA data and LSAR database requirements may evolve as the requirement for access to the data intensifies. There is significant potential for reduction of data requirements in that, with query capability, the Government can generate data, reports, and products on demand rather

than having the contractor prepare and deliver them. As digital data utilization evolves, the media on which the data is delivered will also evolve as depicted on Figure 11-9. [Ref. 11: p 11-24]

b. Contractor Integrated Technical Information Service (CITIS)

Access to digital data will become the standard by which all acquisitions will be measured. Because CITIS provides access to contractor-managed, functionally-integrated information, it must play a significant role in improved Government operations and the streamlining of processes. An effective CITIS program will require foresight and added coordination efforts on the part of contractors, Government sponsors, and potential CITIS users. Functional integration approaches, as well as CITIS performance, must be considered. Measures should be developed to motivate contractors with top-level commitments to produce overall, functional integration and an effective CITIS implementation.

An effective LSA program will be planned, integrated, developed, and conducted in conjunction with the requirements of the overall acquisition program objectives. The LSA process will be established consistent with the type and phase of the acquisition program. To maximize the use of the plans, procedures, front-end analyses and reports developed from selected LSA tasks, it is necessary to establish a viable communication link with the contractor. Providing an early-on CITIS capability (including analyses and documentation generated from the 200 & 300 series tasks of MIL-STD-1388- 1A) will enhance the LSA process and the overall design effort.

There are several considerations facing contractors when they are tasked with providing CITIS to support LSA databases. Areas of consideration include the following.

- Type of DBMS or languages: The number and disparity among database management systems, programming languages, data models, data descriptions or data organizations, and interface and access languages;

- Data element format: The number of discrete techniques for re formatting data to be presented to the user in a predefined, standard format including conversion of units of measure, translation into standard format, and other agreed upon translations or conversions;

- Source or location of data and applications: The user must know the differences concerning location, hardware, operation system, programming language, and access methods for specific systems;

- Relationship and dependencies: The degree to which the user must keep track of data relationships and dependencies within and across integrated data sets;

- Version knowledge and control: The degree to which the user must ensure that data retrieved from more than one system and database are consistent in terms of data values, version or status, and context. [Ref. 11: p. 11-25]

C. ENGINEERING DATA MANAGEMENT SYSTEMS

This section includes two real life examples of improvements and benefits introduced by implementation of CALS in both industry and government engineering document management systems. [Ref. 29: p. 10]

1. ECARDS

General Dynamics (GD), Land Systems Division located in Warren, Michigan has over the past four years implemented the Engineering Computer Aided Retrieval and Distribution System (ECARDS) that is an information management system for raster image data. General Dynamics builds tanks for the U.S. Army and foreign governments. With the implementation of ECARDS, GD has taken the first step in moving toward a paperless production of a defense product: the M1A1 Tank. The current paper based M1A1 repository is being scanned into the system from both paper and aperture card originals. Images are being stored digitally onto optical disk. The system is completely computer controlled, automatic, and has the capability of providing audit logs for the tracking of image file retrieval and printing. The system also has access security built into the user interface application. ECARDS utilizes the MIL-R-28002, Type II CALS standard for all image files. This raster data format known as TRIF (Tiled Raster Interchange Format) is tiled on 512 pixel boundaries and compressed via the CCITT Group IV compression standard. Currently the ECARDS system is limited to storing and retrieving only raster image data. The next step in the evolution of ECARDS is to incorporate both CAD, vector files and technical publishing files. These formats will be implemented using the IGES and SGML standards respectively.

Also recently implemented within ECARDS is the ability to transfer image data to and from the government. The U.S. Army Tank Automation Command (TACOM) is the General Dynamics' largest customer. TACOM has implemented a system called DSREDS

for (Digital Storage and Retrieval Engineering Documentation System). It is now possible for a user of the ECARDS system to send image data, drawings, and documents to the DSREDS system electronically. Also, a user of the DSREDS system can automatically access the ECARDS database to search for and retrieve image files electronically. TACOM users can accomplish this by remotely accessing a 3270 terminal emulation session with the IBM mainframe computer at General Dynamics and interacting with the configuration management application. The second step is the ordering of the desired image file or series of files, upon system approval, through an X-windows user interface session that interacts with the ECARDS storage and retrieval application. The communication media between systems can be a T1 leased line or an internet network. This capability -- government access of contractor database -- is an example of CALS phase II Contractor Integrated Technical information Services (CITIS) implementation. This is just the first step in fully implementing a complete paperless data interchange environment. This project shows how progress is being made to accomplish the goals of CALS objectives in a step by step fashion. [Ref. 29: p. 10]

2. HST TMIS

The Technical Management Information System (TMIS) at the NASA, Goddard Space Flight Center in Greenbelt, Maryland is in the process of being upgraded to support CALS standards. At Goddard, TMIS is used as a complete engineering data management system for the Hubble Space Telescope (HST) project. TMIS is being used as a repository

for all relevant engineering data and technical documentation related to the design, maintenance, and support of the HST. The HST TMIS operation is a real life example of what problems occur when an engineering document management system is implemented according to CALS specifications.

In the past, TMIS consisted of many different databases (one for drawings, one for documents, and others for engineering changes, parts lists, etc.). In order to successfully implement a system that is capable of electronically storing and controlling HST data many things must be done up front. First, the data must have a high degree of integrity; the drawing and document database indexes must match the data. Second, there must be a means of accessing all relevant databases from one system. Third, vendors who supply documentation in support of their products must be willing to supply information via standard electronic means. Fourth, data must be converted to digital form before a full system can be implemented and used.

In the recent past vendors would take product data, engineering drawings, support documentation, training material, repair material, etc., (most of which was generated in electronic form), and send it to the HST TMIS operation in paper form. At that point TMIS operators would be required to digitize this information, index it, and store it in digital form within the TMIS system. This involves (1) going from a digital form (CAD and Word processor generated data) to (2) a paper form, and back to (3) a digital form for input into the system. The costs of this redundant and unnecessary re-digitizing of documentation is what CALS is trying to minimize. TMIS managers are in the process of

eliminating this problem by adopting the capability of accepting data electronically from all vendors. This capability alone will save substantial costs associated with the printing of images, the transportation of printed material, the indexing of the material, and the scanning and digitizing of the material, not to mention the costs of the equipment necessary to do this work.

The goal of HST TMIS managers is to get to a point where all information associated with the HST products can be transferred and accepted electronically through the use of CALS standards. The TMIS system uses the MIL-R-28002, Type II (TRIF) data standard for raster image data. TMIS has the ability to convert TRIF data files to and from other industry standard formats and some that are proprietary in nature. The HST TMIS system is being upgraded with application software that allows for a complete CALS compliant solution by incorporation of off-the-shelf software application programs into the system. TMIS can store, retrieve, and control any type of file (raster, CAD, tech pubs, CGM illustrations, etc.).

HST, TMIS managers have found that supporting CALS standards within your organization or system is only half of the problem. Many problems have been identified in the process of implementing this capability. Requiring the various vendors who supply product data (sometimes hundreds of companies) to supply data in one common format (CALS compliant or not) has proven to be a very difficult thing to do. For example, of the main HST suppliers of information, which consists of approximately seven companies Lockheed Missiles and Space Company, Ball Aerospace, Electro Optics Cryogenics

Division, Hughes Danbury Optical Systems, the University of Arizona, and the European Space Agency, has a different type of CAD system that is used to generate engineering data. It has was discovered by HST, TMIS managers, through a painful process, that the Initial Graphics Exchange Specification (IGES) standard is not supported in the same manner by each CAD system and software vendor. This means that IGES files written by a particular application may not be readable in its entirety by a second vendor MES program. In most cases, character and notation data is what drops out upon electronic data interchange between systems. This data is only recovered by manual means via labor intensive quality control; this is a costly proposition. This problem can only be solved with time, better definition of the standard, and incentive on the CAD manufacturers to implement and/or upgrade field software with CALS compliant versions. It will become increas-ingly more important to each of these vendors as more and more government contracts require CALS compliancy in the future. [Ref. 29: p. 11-12]

V. RECOMMENDATIONS FOR THE ROK ARMY

A. LESSONS FROM U.S. CALS

CALS started as a program that managed several Information Technologies (ITs) to achieve greater efficiency in the acquisition and logistics businesses. Effectively managing IT inherently implies managing change. The ongoing technological revolution within this field shows no sign of abating. IT mangers are subject to the same forces that are forcing change in other area, and are themselves responsible for one of these driving factors of change within business and society. Therefore, much of the writing on implementing IT focuses on change. Furthermore, IT projects like CALS permeate every functional area of the organization, so their changes inevitably require organization-wide adaptation.

One of a manager's critical concerns is IT integration. Integrating IT covers two topics. The first is designing the system so that it is supportive of the enterprise wide goals. The second is the actual implementation of new systems. Both can be accomplished through a common approach. Carol Beatty has identified the factors involved in doing this successfully. She identifies three factors :

- An effective champion. Usually someone with some backing from senior management, this person must especially have the political skills to negotiate among the various coalitions that exist across functional lines.
- A plan for system integration. As self evident as this may seem, only about half of the firms implementing new IT systems have any plan at all for tying together the systems of their firm. Indications are that the most successful

method to date for formulating and implementing these plans are through cross-jurisdictional committees and teams.

- Steering committees and implementation teams. Because of the complexity and interrelatedness inherent in an information system that spans all aspects of an organization, it is unlikely that any one person would have all the expertise and insight to design an optimum system. Even if they did, they would than face a daunting task educating and gaining the support of the many diverse coalitions that exist in any large organization. Steering committees exist at the senior management level with a medium to long range time frame. They are primarily responsible for integrating the IT effort it the organizations overall strategy. The implementation teams represent the users of the system, they are involved in the nuts and bolts of the actual system development. [Ref. 30]

Based on this theoretical framework, I would like find some lessons from the U.S. CALS effort.

1. An Effective Champion

CALS has received support from senior leadership, both the President and the Secretary of Defense. Since September 1985, when CALS was initiated by a memorandum of the Deputy Secretary Defense, Taft, there were several efforts to embed the purposes of CALS in the DoD. At the beginning, the formalizing of the acquisition process by DoD Instruction 5000.2 helped to institutionalize infrastructure modernization by JCALS and Joint EDMICS programs and CITIS development. [Ref. 31: p. 48] Recently in October 1993, President Clinton's memorandum made the use EDI mandatory in new procurement systems being developed across all federal agencies.

A change champion was formally organized as PM JCALS which was definitely a benefit. Unfortunately, the actions of some of their personnel endangered the program, highlighting the need for high quality, well trained people to manage it.

2. A Plan for System Integration

As is the case with many large IT projects, the lack of clearly defined requirements proved to be problematic. In its report, the Government Accounting Office (GAO) criticized JCALS implementation. "There is great uncertainty as to whether JCALS will meet user needs," GAO said. The services, the report noted, have not reached a consensus on format and data content requirements for the technical manuals. According to report, Dr. Tomlinson, PM JCALS program manager, said it probably would take two or five years to come to such an agreement. [Ref. 32]

The Pentagon CALS office said "We understand the need to clearly define the CALS initiative and what it encompasses. We have defined the initiative very clearly in the CALS Phase II Architecture Deployment Plan, which is expected to be circulated by the beginning of the calendar year." [Ref. 32]

Another common problem in IT projects is that of requirements creep. Since CALS's inception in 1985, it has undergone several transformations. DoD intended to computerize the technical and logistics data for weapon system development. In its current form, CALS encompasses the entire life cycle of weapon systems.

GAO said, "Although DoD has expanded the CALS scope, the department has failed to define the initiative and its implementation. Despite the significant potential benefits offered by CALS, there is no single point of accountability for the initiative. Instead, management responsibilities are diffused throughout government and industry." [Ref. 32]

One very positive lesson learned from the U.S. experience is the importance of an evolutionary approach to the acquisition through the use of prototypes for implementation. As aforementioned earlier, DoD estimated a need for over 250 JCALS sites over the world. DoD has tested 6 prototyping sites and Dr. Tomlinson said this : "The Joint Computer-aided Acquisition and Logistics Support (JCALS) program has successfully employed prototyping as part of its evolutionary acquisition strategy. The incorporation of prototyping into the JCALS acquisition strategy is not only a sound design/development methodology but is consistent with the DoD guidance in DoDI 8120.2. Guidelines in this policy instruction show that prototyping may be used throughout the life cycle management process. The prototyping concepts provide an opportunity to significantly reduce risks to the JCALS program and to provide better responsiveness to the users of the JCALS system." [Ref. 33]

3. Steering Committees and Implementation Teams

Good use has been made of steering committees at DoD and DISA, and implementation teams in NIST and industry. Within DoD, the CALS & EDI Office of the Under Secretary of Defense (Acquisition and Technology) is responsible for issuing CALS directives and coordinating CALS efforts among DoD military departments and agencies.

The Defense Information Systems Agency (DISA) is responsible for maintaining DoD information technology standards and conventions. Within DISA, the Center for Standards, part of the Joint Interoperability and Engineering Organization, is the

designated configuration manager for DoD Electronic Commerce/Electronic Data Interchange (EC/EDI) standards. [Ref. 34]

The National Institute of Standards and Technology (NIST), a part of the Department of Commerce, has been tasked to provide the DoD assistance in developing the CALS standards. NIST works with military departments and agencies, industry and national and international standards organizations to develop the CALS initiative standards and make recommendations to the CALS and EDI Office on which standards to implement.

The CALS initiative being, a joint DoD-industry program, is primarily represented by the CALS Industry Steering Group (ISG). The CALS ISG leadership has recently renamed the CALS initiative to Commerce at Light Speed to better reflect the ISG's opinion that CALS strengths rest with Enterprise Integration (EI) efforts in manufacturing.

The CALS ISG has formed Regional Interest Groups (RIGs) to meet periodically with industry representatives to keep them current with the latest CALS developments. At the time of this writing there are CALS RIGs in at least 25 states. [Ref. 7: pp. 11-13]

At the seventh annual CALS conference and exposition on December 6, 1994, the CALS ISG Executive Advisory Council announced the formation of CALS International. CALS International will serve to advance international business by promoting the use of standards and shared digital data in electronic commerce. Presently, there are nine nations with CALS ISG organizations: United States, Canada, United Kingdom, France,

Germany, Sweden, Japan, Taiwan, and Australia. Additional countries are expected to formalize a CALS organization with the announcement of CALS International.

The CALS International will consist of three elements: 1) International Board of Directors (like a steering committee), responsible for setting priorities, defining long-range objectives and forging strategic partnerships and cooperative relationships; 2) the International CALS Congress (like an implementation team), responsible for developing a coordinated approach to implementing CALS requirements; and 3) the International CALS Secretariat, responsible for providing staff support.

4. CALS Culture Shock

Schein identifies the introduction of new technology as a cultural change problem. Benjamin and Blount further indicate that organizations have often not reaped the promised benefits because they have not understood the need to develop new processes when developing new systems. Implementing IT is an organizational change problem, and can be successful only when senior executives are willing to pay the price that complex cultural change entails. [Ref. 35: pp. 36-38]

Secretary of Defense Taft envisioned the bold nature of CALS as a 25-year infrastructure modernization and process improvement effort -- changing the way we do acquisition and logistics. The enabler of that change is the infusion of information technology and the business process re-engineering concepts driving today's changes in information management. Whether one views these changes as evolutionary or revolutionary is a matter of perspective. Regardless of perspective, CALS involves

change! This change has caused the creation of a culture shock within the acquisition and logistic communities of both government and industry. Certain skills will become obsolete and new skills will be developed. These changes trigger both fear and excitement in people, depending upon their individual assessments of how they fit in the future. [Ref. 31]

In their article, in 1993, Davidovich and Heisterberg said CALS culture shock is the result of three discontinuities of understanding between those who see the impact of CALS upon government and industry and those who see CALS as a just another fad or don't even know what the CALS acronym means. They added three reasons of discontinuity; 1) people using the "CALS Military Standards" for an explanation of CALS while others use the various CALS policy statements; 2) resistance by other IT projects from being absorbed into the CALS effort; and 3) CALS advocates who have created an ever increasing and complex CALS lexicon.

Even one of the most advanced countries, the United States, has experienced the cultural shock from this change which they prepared and faced; Korea, a developing country, could also expect these cultural shocks.

To reduce CALS culture shock, they suggest types of actions that are grouped into three themes: education, management, and funding.

Education weakens culture shock by establishing a common understanding of CALS. Group consensus is a visible indication that culture shock is being reduced --

focusing the group to communicate and exchange their problems and solutions on information technology and process improvement matters.

Management has many paths to attack culture shock - establishing a testbed for evaluating, demonstrating and rapidly prototyping CALS/CITIS applications. CITIS offers managers an excellent and practical environment to deal with and overcome CALS culture shock.

Funding is the ammunition that quells culture shock - advocating funding with a focus on a business case, starting a CITIS business case to develop the needed supporting data, and establishing a relationship with DoD laboratories dealing with information technology. [Ref. 31]

B. STATUS QUO OF KOREAN CALS

Now, the interest in CALS is increasing in Korea, i. e., several newspapers introduced CALS, its benefits, successful examples in other countries and the urgency of the implementation in Korea. But this interest on the industry side is greater than on the government side.

Now, in Korea, the CALS Committee of the EDI Office of the Computer and Communication Promotion Association of Korea (CCPAK) plays the leading role for CALS activities on the industrial side. Most of the large industrial conglomerates (Samsung, Hyundai, DeaWoo, Lucky-Goldstar, Oracle System Korea, and etc.) has

started studies focusing on CALS. CCPAK has held "CALS Korea : the International Conference & Exhibition" in 1994 and 1995.

On the government side, the Ministry of Information & Communication (MIC) and the Ministry of Trade, Industry & Energy (MTIE) have established long term plans for CALS. In February 1995, MIC announced that it will spend 100 Millions Won (US $ 125,000) to establish the master plan for CALS that set out the Korean CALS vision and provide direction for a systematic push in this year.

MIC will use this master plan as a basic guide line for the national CALS implementation and the plan to connect with the Industry Information Network project. They will also use it to create development plans to fit the character of the each industry.

MIC plan to establish the "CALS Korea Co-operation Committee (CKCC, proposed)" from the CALS Committee of CCPAK with related institutes and associations, CKCC will analyze CALS related businesses, urge co-operation between associations and companies, and take a role for consulting and assisting international projects. [Ref. 36]

Also MND is studying the issue to develop a basic plan for Korean CALS setup. More detailed plan will be developed by the Korea Institute for Defense Information System (IDIS). Additionally, the Agency for Defense Development (ADD) will develop an Integrated Weapon Systems Data Base (IWSDB) as a model for the services.

C. RECOMMENDATIONS

This section presents some recommendations for a Korean CALS Implementation plan.

1. Use The Prototype Implementation Strategy

A prototype strategy will avoid the large sunk investment in rapidly changing technologies. Prototypes will train people and help overcome resistance and culture shock. This process can itself take years, so we need to start these processes early in our effort.

The Korean Armed Forces (KAF) has a relatively small size compared to the United States'. Instead of one or two prototyping sites in each service, a joint prototyping site which has departments of each service could be tested and demonstrate several CALS projects on the same equipment. It could help avoid potential conflicts from use of different standards in each service from the beginning of the implementation.

2. Exchange Personnel to Effect Technology Transfer

Professor Thomas J. Allen from the Sloan School of Management at MIT did extensive research into the process of technology transfer under the sponsorship of the U.S. National Science Foundation. The main finding of his analysis, now widely accepted, is that the most effective way of transferring technology is through the relatively long term exchange of personnel. Personnel assigned to an outside organization establish a network of informal contacts outside of their native organizations and then tend to serve as "gatekeepers" who continue to bring fresh ideas into their organizations long after their

return. Personnel from outside the organization who come to work inside on a day to day basis, tend to stimulate a higher level of activity and exchange of ideas. [Ref. 37]

Based on Allen's research, it would be available to exchange personnel between the U.S. and Korean CALS efforts, for example: 1) send liaison personnel from Korean CALS project Office to JCALS or DISA for long term assignment (1 to 3 years); 2) try to get some manpower from the U.S. ISG or a consulting contractor from the U.S. to work in Korea to establish a Korean ISG through CALS International.

3. Establish Standards

We found sufficient reasons why we should introduce CALS as soon as possible. Nowadays the Korean domestic defense industry already has some degree of capability to develop new weapon systems (e.g., K1 tank in Army, FFK, destroyer level of ship in Navy). Unfortunately, those developments were done without a full architecture of the CALS consideration. Maybe some of the industrial CALS-compatible applications (e.g., EDI, SGML) are partially used by big businesses (not in the military project but in the business trade or other purpose) but not integrated together. The most problematic issue is that there are no documented standards for the CALS environment of Korea. Therefore the most urgent phase of the CALS implementation should be the establishment of standards. As the U.S. CALS standards set their direction for the international integration of CALS, it will be preferable for MND to follow the format of the U.S. standards. For KFP, at least five classes of standards are needed. Those are 1) SGML for the text standard, 2) IGES for the vector graphics, 3) CCITT Gr. 4 for raster graphics, 4)

MIL-STD-1388-2D for the logistics data, and 5) MIL-HDBK-59B for overall instruction about data acquisition and usage.

4. Build Defense Information Infrastructure

After the standards have been established, the real architecture design for CALS will be possible as the next phase of CALS implementation. For example, the three big contractors for the Korean Fighter Plane (KFP) could have the engineering data depository and other 100 subcontractors might have CALS network capability. For CALS data transmission, a 100 Mbps network capability is required. To acquire this transmission capability, the MND project launched recently might be done with optical fiber. When we consider the huge amount of the KFP investment, the cost of building the network is quite modest. Therefore, a good chance exists to obtain funding for infrastructure construction.

VI. CONCLUSION

The goal of CALS is to move from the traditional, paper-based organization to an integrated digital information-oriented enterprise. However, achieving this transition will require new management approaches and the cooperative involvement of the participating enterprise in solving current and future problems, such as organizational and cultural issues, legal and security issues, technology selection, and the integration of legacy data. [Ref. 2, p 58]

The Government and the Military of the Republic of Korea, having recognized the potential benefits of CALS, is now in the process of defining its implementation strategy and plans. Additionally, MND is actively exploring CALS for the benefits described above, and to improve interoperability with Korea's military allies.

The conclusion reached by this thesis research is that it will be a matter of how, rather than if, the Korean MND will incorporate CALS into its operations and infrastructure. The scope of CALS has grown to the point that it now represents the bulk of the information technology revolution as it impacts on the materiel support of a modern military.

Learning from the U.S. experience, we see that the challenges of CALS spring from both the technology involved and its pervasive organizational impact. Organizationally, it is important to involve all stakeholders in the process to address their concerns and achieve "buy in." To maintain discipline in the process a single arbiter must

be in charge and an explicit plan is required to coordinate the many diverse efforts. The impact of changing procedures and culture must be anticipated and addressed.

The technological challenges of CALS descend from the rapid rate of change of the technology, and the difficulty of establishing standards. The long lead time required for infrastructure installation requires an early effort to build, but for other components of the system (e.g., processors, storage, display, and software) the use of prototype and a phased, modular procurement approach will allow a more cost effective way to benefit from incremental technological development.

The definition of international standards is currently underway by the CALS ISG. It is concluded that it would be to the benefit of Korea to participate in this process by exchanging personnel. This would ensure that Korean requirements are included, such as Korean letter standards, and that Korea remains on the leading edge of technological development and military prowess.

APPENDIX: ACRONYM

ADD	Agency for Defense Development
AIIM	Association for Information and Image Management
AIS	Automated Information Systems
ANSI	American National Standard Institute
AP	Acquisition Plan
AP	Application Protocol
ARM	Application Reference Model
ARPANET	Advanced Research Project Agency computer NETwork
ASCII	American Standard Code for Information Interchange
ASME	American Society of Mechanical Engineers
BBS	electronic bulletin boards
CAC	Contractor's Approach to CALS
CAD	computer-aided design
CALS	Continuous Acquisition and Life-cycle Support *or* Computer-aided Acquisition and Logistics Support
CALS ISG	CALS Industrial Steering Group
CBC	ConstructionBattalion Center
CCPAK	Computer and Communication Promotion Association of Korea
CCITT	Consultative Committee for International Telegraph and Telephone
CDRL	Contract Data Requirements Lists
CD-ROM	Compact Disk Read Only Memory
CE	Concurrent Engineering
CGM	Computer Graphics Metafile
CIM	Corporate Information management
CITIS	Contractor Integrated Technical Information Services
CKCC	CALS Korea Co-operation Committee
COTS	commercial-off-the-shelf
DDN	Defense Data Network
DFARS	Defense Federal Acquisition Supplement
DII	defense integrated infostructure
DISA	Defense Information Systems Agency
DISN	Defense Information Systems Network
DLA	Defense Logistics Agency
DoN	Department of Navy
DoD	Department of Defense
DPS	Defense Printing Service
DSREDS	Digital Storage and Retrieval Engineering Data System
DTD	Document Type Definition
EAC	Electrical Applications Committee

EC	Electronic Commerce
ECAT	Electronic Commerce Acquisition Team
ECARDS	Engineering Computer Aided Retrieval and Distribution System
EDCARS	Engineering Data Computer-Assisted Retrieval System
EDI	Electronic Data Interchange
EDIF	Electronic Design Interchange Format
EFT	electronic funds transfer
EI	Enterprise Integration
EMD	Engineering and Manufacturing Development
FIPS	Federal Information Processing Standard
FOSI	Formatting Output Specification Instance
FDDI	Fiber-Optic Distributed Data Interface
FRC	Final Reproducible Copies
FTAM	File Transfer and Access Management
GAO	Government Accounting Office
GCO	Government Concept of Operations
GD	General Dynamics
GDMS	Global Data Management System
GD/DDB	Global Dictionary/Directory Data Base
GFI	Government Furnished Information
GOSIP	Government Open Systems Interconnection Profile
HST	Hubble Space Telescope
HTTP	HyperText Transfer Protocol
HUI	human-user interface
IGES	Initial Graphics Exchange Specification
IAW	in accordance with
IDIS	Korea Institute for Defense Information System
IETM	Interactive Electronic TMs
ILS	Integrated Logistics Support
IMS	information management system
IPC	Interconnecting and Packaging Electronic Circuits
IPO	IGES/PDES Organization
ISO	International Organization for Standardization
IT	Information Technologies
IWSDB	Integrated Weapon Systems Data Base
JCALS	Joint Computer-aided Acquisition and Logistics Support
JEDMICS	Joint Engineering Data Management and Information Control System
KAF	Korean Armed Forces
KIDIS	Korea Institute for Defense Information System
KFP	Korean Fighter Program
LCC	Life Cycle Cost
LEM	Logistic Element Manger

LEP	Layered Electrical Products
LRU	Line Replaceable Units
LSA	Logistic Support Analysis
LSAR	Logistic Support Analysis Record
MIC	Ministry of Information & Communication of Korea
MND	Ministry of National Defense of Korea
MTIE	Ministry of Trade, Industry & Energy
MLS	multi-level secure
NII	national information infrastructure
NIST	National Institute of Standards and Technology
ODA	Open Document Architecture
OS	Output Specification
O&S	Operation and Support
OSI	Open Systems Interconnection
PC	Personal Computer
PDL	Page Description Language
P&D	Production and Deployment
PHD/NSWC	Port Hueneme Division, Naval Surface Warfare Center
PMC	President's Management Council
PM JCALS	Program Manager JCALS
RFP	Request For Proposal RFP
RIG	Regional Interest Groups
RISC	Reduced Instruction Set Computing
ROK	Republic of Korea
SGML	Standard Generalized Markup Language
SOSC	System operational Support Center
SOW	Statement of Work
TACOM	Tank Automation Command
TCP/IP	Transmission Control Protocol/Internet Protocol
TDCC	Transportation Data Coordinating Committee
TDP	Technical Data Package
TMCR	TM Contract Requirements
TMIS	Technical Management Information System
TMs/TOs	Technical Manuals or Technical Orders
TRM	Technical Reference Model
USFK	United States Forces in Korea
UN/EDIFACT	United Nations/Electronic Data Interchnage For Administration, Commerce, and Transport
VAN	Value-Added Communication Network
VHDL	Very Hardware Description Language
VHSIC	Very High Speed Integrated Circuit
VT	Virtual Terminal
WORM	Write Once Read Many-times

WRA	Weapon Replaceable Assemblies
WSS	Workstation Server
WWW	World Wide Web

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